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The Report of BLUE OCEAN SHIELD Ballast Water Management System Onboard Test

System developers:

COSCO Group;

Tsinghua University

Test institutions:

Beijing PONY Testing Center;

Weihai Marine Environment Monitoring Stations of the State Oceanic Administration

Witnessed by:

China Classification Society (CCS)

Contents

1 Test background

1.1 Description of COSCO ballast water management system (BLUE OCEAN SHIELD)

China Ocean Shipping (Group) Company (hereinafter referred to as COSCO) and Tsinghua University jointly developed a modular ballast water treatment system (BLUE OCEAN SHIELD). The filtration system is in front of the UV system, whose role is to remove particulate matters and other impurities while removing plankton larger than 50μm. The operation and self-cleaning of the filtration system do not affect the UV treatment process, and the flushing fluid for self-cleaning is discharged into the sea area collecting water. High doses of UV produced by the UV system can inactivate the majority of algae, bacteria and other microorganisms in the water body for treatment.

The ballast water is subject to treatment once at the water inlet, and then to separate UV treatment once at the water outlet. The treatment at the water inlet is to ensure the entry of minimum active organisms into the ballast tank. Discharge of ballast water after treatment is to avoid any possible surviving organisms in the ballast tank.

Ultraviolet (UV) radiation can effectively inactivate the microalgae, bacteria and viruses, which not like other disinfectants, does not result in

any by-products [Chang, JCH et al. 1985; Hijnen, WAM et al. 2006], and therefore, UV disinfection is very suitable for the application in ships' ballast water treatment.

UV inactivation mechanism is: Base pairs in DNA or RNA (thymine and cytosine in DNA and uracil and cytosine in RNA) absorb UV for photochemical reaction and form chemical dimers therebetween. These dimers block the replication of DNA or RNA strands during the cell division. Thus, UV radiation may be used for inactivation and disinfection (Bolton et al, 2003).

The filtration and UV based ballast water treatment has the following main advantages:

- UV will not cause pollution to the local seawater ecology while reducing the number of microorganisms, which is one of the most environmentally friendly treatment methods
- Disinfection is conducted when water flows through equipment without additive active inactivator;
- Free of toxic by-products
- No corrosion to ballast water tank
- Low maintenance cost of treatment equipment, and easy to operate
- Ensure minimal operational costs and the highest operational safety

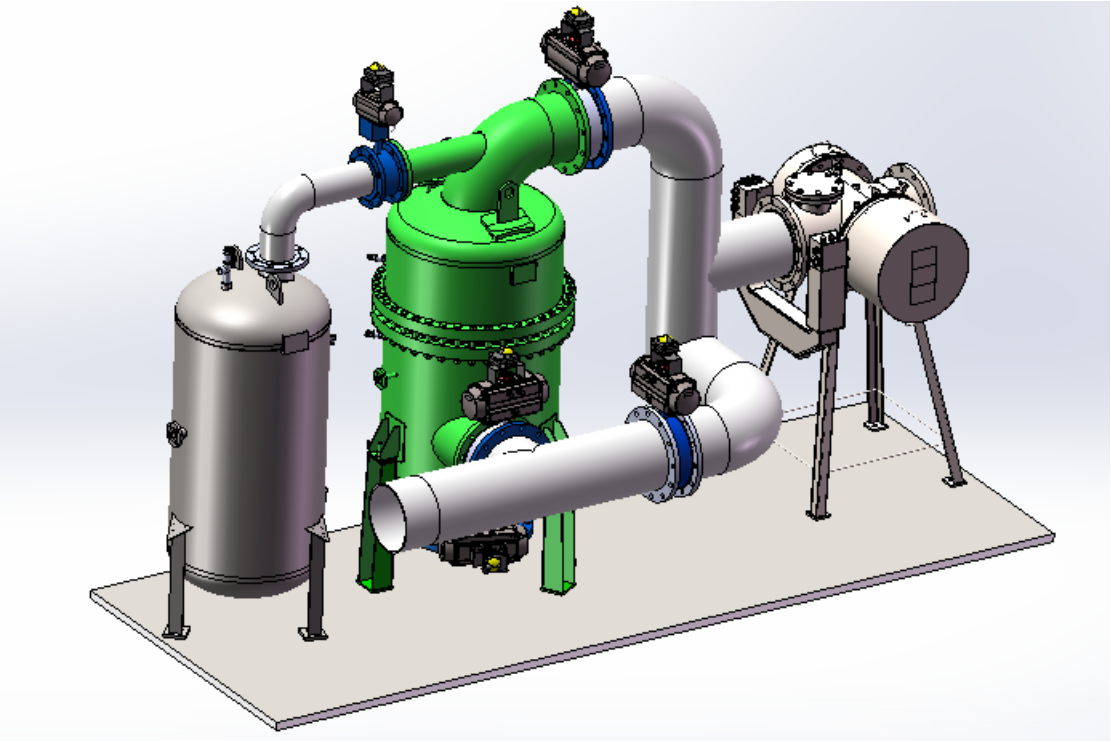

Figure 1-1 Overall structure of BOS system

BLUE OCEAN SHIELD is a complete system, composed of three main functions:

1 Filter

The filter can separate solid particles larger than 50μm. Blue Ocean Shield system uses multi-element tubular filter element technology. Cleaning of filter element uses high pressure gas on the ship. The filter can satisfy uninterruptible overflowing and make sewage generated by filtration to be discharged from blow-off pipe to the port sampling water without any effect on the local biota populations.

Technical parameters of filter:

Flow rate: 600m^3/h

Filter fineness: 50μm

Working pressure: 0.58MPa

Maximum working pressure: 1.0MPa

- Water consumption by self-cleaning (percentage of treated water) :<1%
- Material:

  Cavity of filter: Q345R, inner wall heavy duty anti-corrosion coatings

  Filter screen: 316L

Figure 1-2 Overall structure of BOS filter

2 UV disinfection system

UV disinfection system does not require any additional chemicals and uses UV disinfection to remove the bacteria, algae and other microorganisms less than 50μm.

Flow rate: 600m^3/h

UV lamp: Medium-voltage UV lamp

Material of cavity of UV reactor: 316L

Dose: 200mJ/cm^2

Automatic washing quartz sleeve

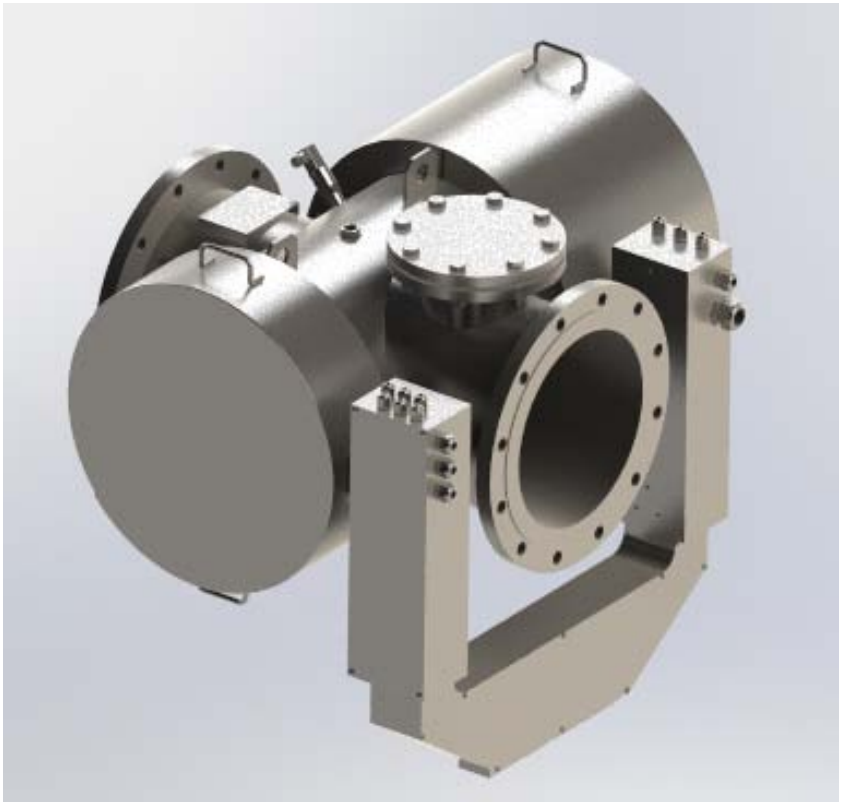

Figure 1-3 Ultraviolet reactor

3 **Control system**

Control system consists of system control cabinet, remote control cabinet, sensing system and executive element. It can finish automatic control of ballast and unloading, and the manual operation of equipment

debugging and emergency situation.

Blue Ocean Shield can be considered as a flexible modular system that can be configured based on the user needs. Filter, ultraviolet reactor and electrical system used for tests on the ship are approved by China Classification Society.

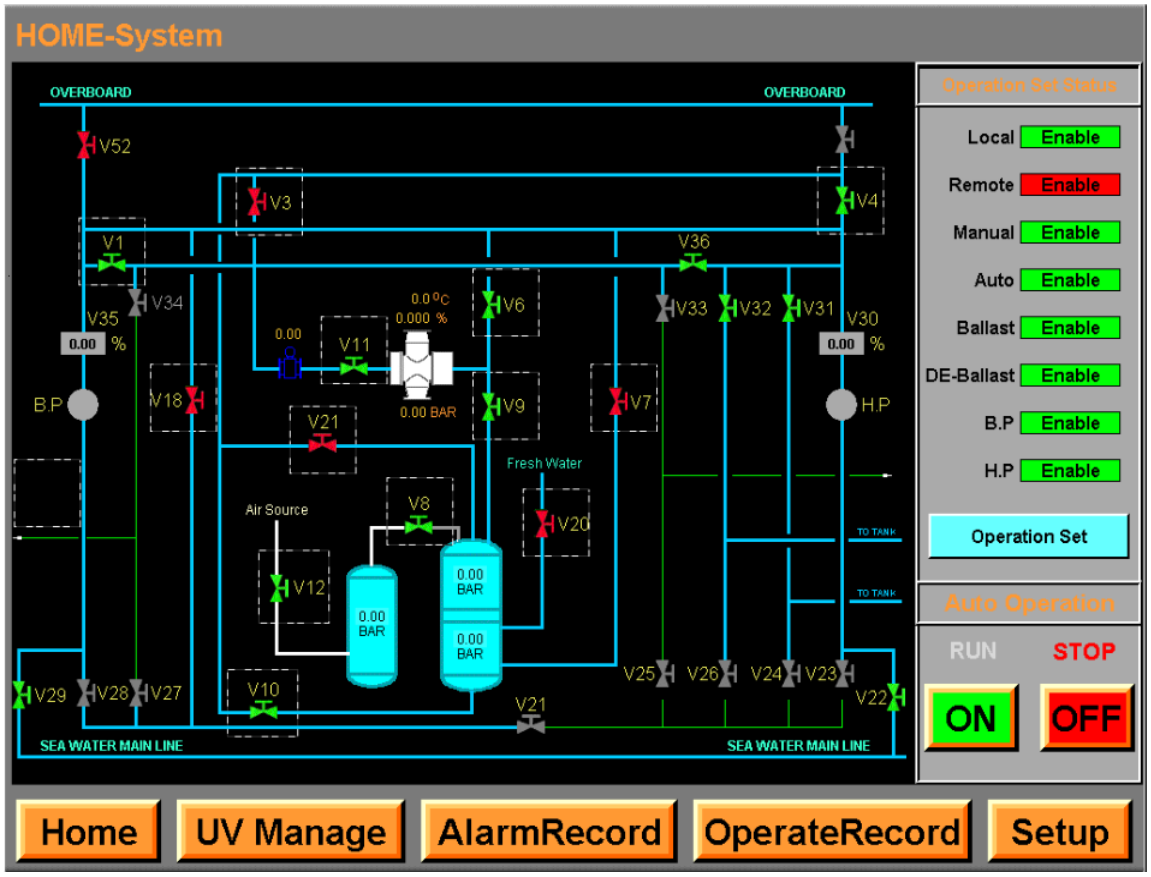

Figure 1-4 Main interface of display screen (i.e. Home interface)

1.2 Responsibilities of test participants

1.2.1 Mode of project organization

1) System developers:

COSCO Group;

Tsinghua University

2) Test institutions:

Beijing PONY Testing Center;

Weihai Marine Environment Monitoring Stations of the State Oceanic Administration;

local detection unit where dock sampling water for ship test

3) Witnessed by:

China Classification Society (CCS)

1.2.2 China Ocean Shipping (Group) Company (COSCO);

China Ocean Shipping (COSCO) is a large-scale transnational business group which mainly engages in international shipping, logistics wharfs and ship building. Centered on Beijing, the Group has nine regional companies as radiant points---Hong Kong, America, Europe, Singapore, Japan, Australia, Korea, West Asia and Africa. The Group owns more than one thousand enterprises and branches in more than 50 nations and regions. The total number of employees is about 130 thousand, including more than 400 employees overseas and more than 4000 foreign employees. The total assets are more than RMB 300 billion, more than half of which is oversea assets and income. A complete global business chain integrated with shipping, logistics, wharfs and ship building is forming. COSCO Shipbuilding Industry Company is a large-scale comprehensive state-owned enterprise which is directly

affiliated to COSCO. The subsidiary companies of this Company

The providers of ballast water management system provide prototypes used for the test, operation and management manual of the system (O&M manuals, including the system’s technical description). The providers also assist the land-based facility providers with the equipment installation and are responsible for the calibration and debugging of the system.

Main responsibilities:

（1）Financial support;

（2）Training for personnel on board for ship test;

（3）Provide the ship for test, install equipment and coordinate ship test;

（4）Applicability evaluation for using system onboard.

1.2.3 Tsinghua University

Tsinghua University, located in Beijing, China, was established in 1911 under the name “Tsinghua Xuetang” and was renamed “Tsinghua School” in 1912. The university section was founded in 1925 and the name “National Tsinghua University” was adopted in 1928. With the motto of “Self-Discipline and Social Commitment" and the spirit of “Actions Speak Louder than Words”, Tsinghua University is dedicated to the well-being of Chinese society and to world development. Nowadays,

Tsinghua, as one of China’s most renowned universities, has always been listed in the national and foreign university rankings.

Tsinghua University is responsible for the research and development of the ballast water management system. It offers the prototypes for the tests and System Operation and Management Manual (O&M Manual, including system technology instructions, parameters, emergency procedure, etc.), puts forward the specific test requirements, verifies the parameters, and formulates plans for environment, health and safety. Tsinghua University assists the equipments suppliers of land-based tests in installing the equipments, and is responsible for the calibration and debugging of the system. It also prepares and collects all materials required for pattern type approval, including application documents, QAPP, etc.

Main responsibilities:

（1）Design, debugging and maintenance of testing system;

（2）Organization of detection conditions, management and coordination of testing program;

（3）The quality guarantee plans.

1.2.4 Beijing PONY Testing Center

Pony Test Science and Technology Co., Ltd. has the qualifications of China National Accreditation Service for Conformity Assessment (CNAS)

and China Metrology Accreditation (CMA). Test reports have the international credibility due to the mutual recognition agreements with up to 58 countries and regions such as America, Britain and Germany. It has established 6 large-scale laboratories in homeland, 8 subsidiaries and 29 affiliated agencies in Britain, Hong Kong and other regions, with more than 1,000 employees totally, which form the global detection network. In 2007 and 2008, the company has been continuously awarded Deloitte “Technology Fast 50, China” and Deloitte “Technology Fast 500, Asia Pacific”, becoming the first institution that has obtained this special honor.

Main responsibilities:

（1）Detect raw water quality;

（2）Detect bacteria.

1.2.5 Weihai Marine Environment Monitoring Station of the State Oceanic Administration

Weihai Marine Environment Monitoring Station of the State Oceanic Administration, established in October 2003, includes the following institutions: Weihai Oceanic Environment Monitoring Centre, Weihai Fisheries Environment Monitoring Centre, Weihai Marine Products Quality Supervision & Inspection Centre, Weihai Aquatic Animal Epidemic Prevention Supervision & Management Station and Weihai

Fishery Disease Control Center. Weihai Marine Environment Monitoring Station is a “Six in One” non-profit public institution which was established by Station of the State Oceanic Administration and Weihai government. The Station is devoted in Weihai oceanic environment monitoring, marine products quality inspection and aquatic animal epidemic prevention and quarantine, owning an office, a quality management department and laboratories. The laboratories take up 500 square meters, with the equipments valued RMB 15 million. The Station has several qualifications, such as the argument of use of sea areas, the evaluation of oceanic environment effects, the evaluation of fishery pollution and loss accidents, marine surveying, marine products quality inspection, and aquatic animal epidemic prevention supervision.

Main responsibility: Marine plankton inspection.

1.2.6 Local detection unit where dock sampling water for ship test

As the allowed preservation time of sample of bacterial detection is less than 18 hours, inspection at the testing institution where water is sampled for ship test is a detection scheme that can be adopted in ship test. Local testing institutions need to be equipped with qualification of CNAS laboratory （ISO17025） and authorization of test item. In the sampling for ship test conducted in Shenzhen, detection of vibrio cholerae was

completed by Shenzhen Entry-Exit Inspection and Quarantine Bureau. This institution has passed CNAS certification. The test items include detection of vibrio cholerae.

Main responsibility:Vibrio cholerae detection.

1.2.7 China Classification Society

Founded in 1956, China Classification Society (CCS) is the only specialized organization of China to provide classification inspection services of ships. CCS aims to provide services for the shipping, shipbuilding, offshore exploitation and related manufacturing industries and marine insurance by furnishing reasonable and reliable classification requirements and providing independent, impartial and integral classification and statutory services to ships and offshore installations, for the promotion and safeguarding of the safety of life and property at sea and for the prevention of pollution to the marine environment. CCS defines its basic business nature as “Risk Management” and focuses on “four major business lines and two supporting safeguarding systems,” featuring ship classification inspection, domestic ship inspection, offshore engineering inspection and industrial services—the four major business lines, and the rules & research and the information technology services—the two supporting systems. By sticking to the policy of “building a first-rate international classification society with unique

characteristics upon technology and trust", CCS is striving to forge a CCS quality brand and has made remarkable achievements.

Main responsibility: Witness and supervise the whole process of ship test.

1.3 Introduction of ship for onboard test and description of modification

1.3.1 Introduction of ship COSCO ROTTERDAM

Introduction of ship for loading

Ship name	**Ship type**	**Nationality**	**Total ballast water volume (m^3)**	**Design flow of ballast water (m^3/h)**	**Main routes**
COSCO ROTTERDAM	5250TEU container ship	UK	15,329.4	600	Asia to Mediterranean Sea

BOS ballast water system is loaded in Zhoushan, Zhejiang.

Figure 1－5 COSCO ROTTERDAM

1.3.2 Ballast water pipeline structure after loading of BOS system

BOS ballast water management system is installed based on the ship's existing piping system and the structures of the ship's ballast water pipes before and after installation are shown in Figure 1-6 and Figure 1-7:

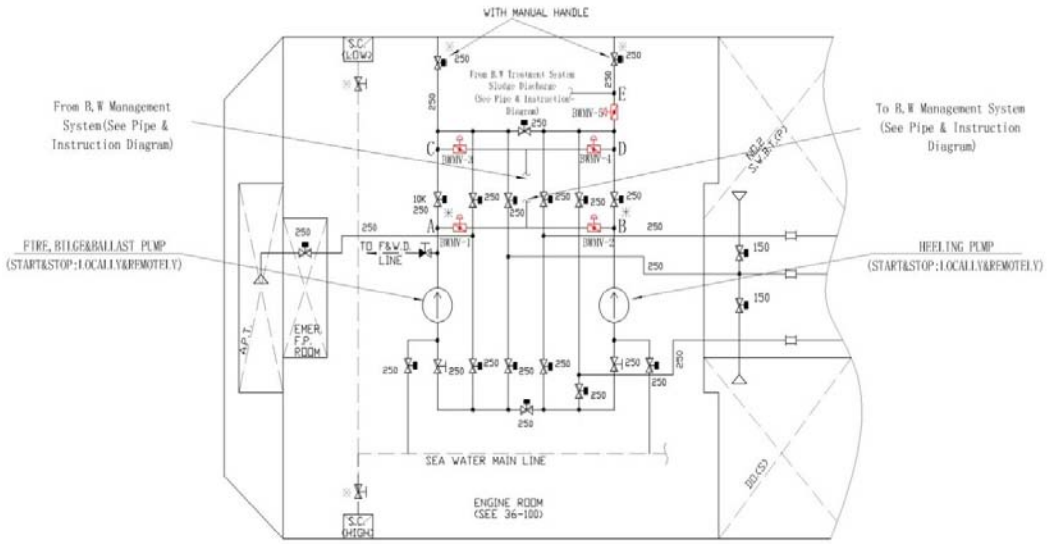

Figure 1-6 Ballast water pipe diagram

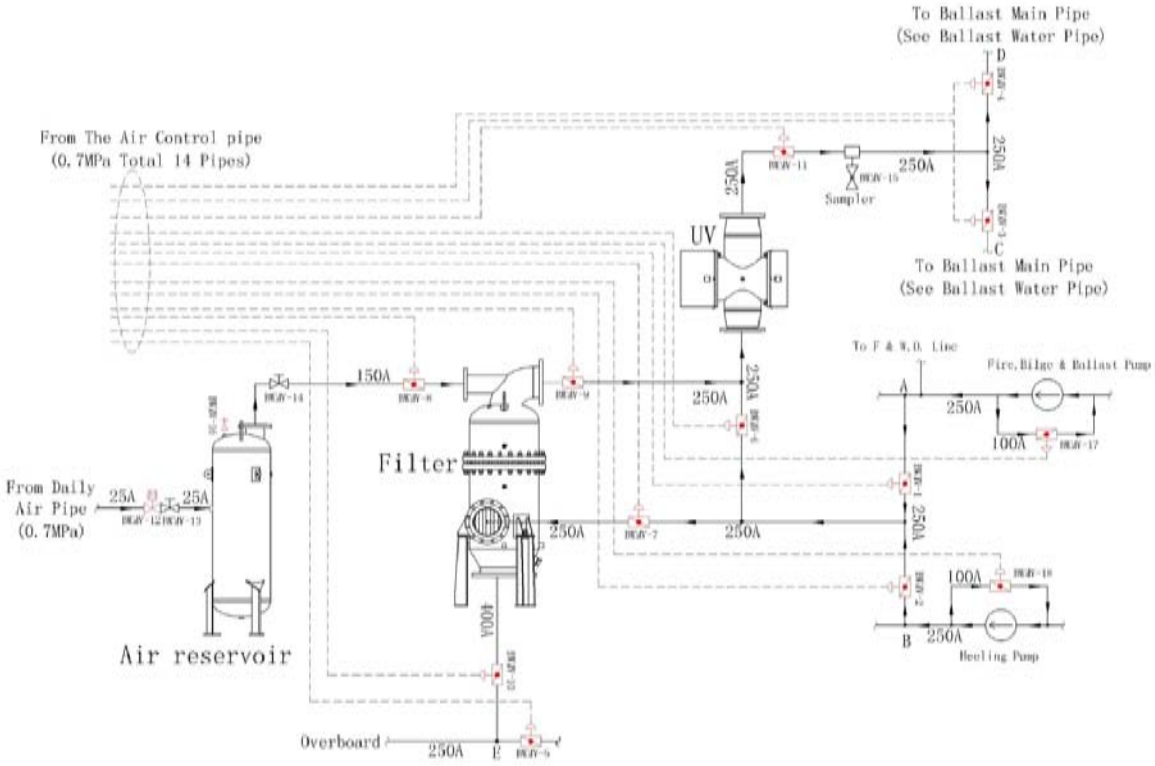

Figure 1－7　　BOS system pipeline connection

1.4 Test purpose

The purpose of shipment test of Blue Ocean Shield ballast water management system is to evaluate if the Blue Ocean Shield ballast water management system meets the requirements for biological effectiveness, acceptability of real ship, etc. In the Ballast Water Convention and Guidelines, and the onboard test is subject to G8 in the Ballast Water Convention.

2 Test content and methods

2.1 Test content

Ship test content includes:

- Test of overall function of BOS system
- Test of bio-availability

The test of overall function of BOS system is used for inspecting basic design function of equipment. The detection content includes: Implementation of actuator movements, accessibility of communication and control lines, whether instruments and apparatus, function of alarm and failure logging work normally, and stability of continuous working of equipment.

Test content of bio-availability includes: Detection of concentration of plankton and bacteria provided in G8 and D2 (before and after test). The water quality needs to meet requirements of G8. Test items include: plankton, escherichia coli, enterococcus and vibrio cholerae.

According to provisions of G8, some water quality indices shall also be monitored，mainly including: Salinity of influent water, temperature, DOC (dissolved organic carbon), POC (particulate organic carbon), TSS (total suspended solids), residual chlorine, turbidity, pH, etc.

2.2 Test basis and method

According to the related normative documents of OECD, USEPA and other authoritative organizations, the test methods are shown in Table 2-1.

Table 2-1 Reference standards for detection

Test content	Reference standards
Determination of E. coli	*Microbiological Examination Rules for Ballast Water of Entry-exit ships* SN/T 1875-2007 *Microbiological Examination of Food Hygiene-- Enumeration of Escherichia Coli* GB/T 4789.38-2008
Determination of Vibrio cholerae	*Microbiological Examination Rules for Ballast Water of Entry-exit ships* SN/T 1875-2007 *Inspection Codes for Cholera at Frontier Port* SN/T 1239-2003
Determination of enterococcus	*Microbiological Examination Rules for Ballast Water of Entry-exit ships* SN/T 1875-2007 *Examination Methods of the Fecal Streptococcus Group in Commodities for Export* SN/T 0475-95 *Detection of Enterococci in Food and Water* SNT 1933-2007
Determination of plankton larger than 50μm	*Oceanographic Survey-Part 9: Guidelines for Marine Ecological Survey* GB/T 12763.9—2007 Technical Specification for Marine Ecological Survey: Ocean Press
Determination of plankton between 10-50μm	*Oceanographic Survey-Part 9: Guidelines for Marine Ecological Survey* GB/T 12763.9—2007 Technical Specification for Marine Ecological Survey: Ocean Press
Determination of water quality indices	*Method for Monitoring and Analyzing Water and Waste Water (the fourth edition)* *The Specification for Marine Monitoring- Part 4: Seawater Analysis* GB 17378[1].4-1998

2.2.1 Bacteriological test method

a) E. coli test

According to the relevant national standards, E. coli test is subject to the following processes:

1）Multi-tube method: Use a 1ml micropipette to draw 1ml homogeneous sample solution, inject it slowly along the wall into the test tube containing 9ml sterile saline solution, shake the test tube to mix them completely and prepare a 1:10 homogeneous sample solution.

2）Follow the above steps to prepare a series of 10-fold increment uniform sample solutions successively, dilute once for every increment and change for a 1ml sterile pipette.

3）Initial fermentation test: For each sample, select three appropriate uniform sample solutions with successive dilutions, and transfer 3 tubes of LST broth into each dilution of sample, with each tube of 1ml. Culture them at 36℃ for 24h and observe if there are any air bubbles in the small inverted tube, and if no, continue to culture for 48h. Record the number of tubes of LST broth where air bubbles are generated from 24h to 48h. If no air bubbles are generated in all tubes of LST broth, report immediately E. coli MPN result; if air bubbles are generated in some tubes of LST broth, carry out the secondary fermentation test on them.

4）Second fermentation test: Use the inoculating loop to take a loop of culture from each of LST broth tubes generating air bubbles within 48h, transfer it to the EC broth tube pre-warmed to 45℃ and place it in the 44.5℃ water bath tank with cover. Make the level of water bath higher than the level of broth medium, culture for 24h, check if there are any air bubbles in the small inverted tube, and if no, continue to culture for 48h.

Record the number of tubes of EC broth where air bubbles are generated within 24h and 48h. If no air bubbles are generated in all tubes of EC broth, report immediately E. coli MPN result; if air bubbles are generated in some tubes of LST broth, carry out EMB plate isolated culture.

5）Plate isolated culture of eosin methylene blue: Gently shake the tubes generating air bubbles, use a inoculating loop to take and mark the culture and inject it to the EMB plate, and culture it at 36℃ for 18h to 24h. Test if there are glossy or matte typical colonies at the black center of the plate.

6）Slant culture of nutrient agar: Pick out 5 typical colonies from each plate, and if there are no typical colonies, pick out the suspected colonies. Use transfer needle to contact with the center of the colony, transfer it into the nutrient agar slant, and culture it at 36℃ for 18h to 24h.

7）Pick out and transfer the colonies to the chromogenic medium of E. coli, and if there appear blue or purple colonies on the chromogenic medium, then E. coli is positive.

8）Report of E. coli MPN count: E. coli is Gram-negative non-spore bacillus, fermenting lactose and producing acid and gas, and as long as there is a colony identified as E. coli, then its represented LST broth tube is positive in E. coli. Check MPN table based on the number of positive LST broth tubes, and report MPN of E. coli per milliliter sample.

b) Test of enterococcus

According to the relevant national standards, enterococcus test is subject to the following processes:

1) Filter membrane method: Clip the edge of sterile filter

membrane with a bore diameter of 0.45μm with a sterile forceps, place it onto the sterilized filter bed with the side with meshes upward, fix the filter, inject 100ml of water sample into the filter, and conduct suction filtration at -0.5 atmospheric pressure.

2) Extract air for 5s after the water sample is filtered, close the vacuum pump, clip the edge of filter membrane with a sterile forceps, place it on KF plating medium with the side holding back bacteria upward, completely press filter membrane against the medium without bubbles between them, and then place the culture dish upside down and place it in an incubator at 36℃for 48±2h.

3) Enterococcus form dark red or red bacterial colonies on KF. Count □ bacterial colonies with the above characteristics, and report content of Enterococcus in 100ml.

c) Test of Vibrio cholerae

According to the relevant national standards, Vibrio cholerae test is subject to the following processes:

1) Enrichment culture: As there are enough vibrios in water sample, it is unnecessary to multiply bacteria in water sample.

2) Separation: Dilute the water samples sequentially to 10 times by the gradient, pipette 1ml sample of each dilution to TCBS agar medium, culture at 36℃ for 24h, and if the colony is yellow, large and smooth, slightly flat, neat in edges, and opaque in the subtransparent center, it is the suspected Vibrio cholerae colony.

3)Identification

4)Pick out from the isolation medium the suspected colonies for slide agglutination test together with diagnostic sera for specificity of O1 Vibrio cholerae colony and O139 Vibrio cholerae colony. If there appears quickly visible agglutination of suspected colonies in the sera (usually in

10s), those without agglutination in normal saline are determined as positive, and those with no noticeable agglutination of particles within two minutes are determined as negative in Vibrio cholerae. When there are too many suspected colonies, pick out five or more colonies for slide agglutination test one by one, and if necessary, take the transparent part at the edge of the originally marked colonies for another slide agglutination test; and when they are all negative, report the O1 colony and O139 Vibrio cholerae colony are not detected. Those agglutinated with the diagnostic serum for specificity of O139 Vibrio cholerae colony are determined initially as O139 Vibrio cholerae colonies, and those agglutinated with the diagnostic serum for specificity of O1 Vibrio cholerae colony are initially determined as O1 Vibrio cholerae colony.

5)Pure culture: Use the inoculating loop to pick out a marked single colony positive after slide agglutination test and transfer it to the nutrient agar plate for purification, culture it at 35℃ for 6h to 24h, and take a single pure colony for morphological examination, dynamic examination, biochemical identification and serotyping.

6)Morphological examination: Take pure bacteria for Gram stain according to GB/T 4789.28, and Vibrio cholerae is a Gram-negative bacterium, slightly short campylobacter, and sporeless.

7) Dynamic examination

8) Semi-solid method: Use transfer needle to pick out pure colonies for puncture on the semi-solid agar, culture at 35℃for 8h to 10h, and if it diffuses along the puncture line and causes the medium to become turbid, it is positive in dynamic.

9) Hanging drop method: Use hanging drop method for preparation of a tablet, observe it under the high power microscope, and if short

campylobacter is in shuttle-like or linear motion, it is positive in dynamic. O1 and O139 Vibrio cholerae colonies are positive in dynamic.

10) Oxidase test: Use the inoculating loop to take a loop of fresh nutrient agar culture and place it on the sterile white filter paper, add a drop of oxidase reagent, and if it becomes pink-violet-black purple in one to two minutes, then it is positive in the oxidase test and oxidase reagent of Vibrio cholerae is positive.

11) Mucous thread test: Add a large drop of 0.5% aqueous solution of sodium deoxycholate to the clean slide, use the inoculating loop to take a loop of fresh nutrient agar culture and place it next to the reagent for grinding, and then mix it with the reagent to prepare a thick suspension; after continuous grinding, the Vibrio cholerae suspension becomes clear and highly thick within one minute; when the loop is used for picking, filaments can be drawn. The negative bacteria after mucous thread test are in the form of homogeneous suspension, and it is the same as the distilled water.

12) Serum analysis: Pick pure colonies on the nutrient agar plate, use Ogawa and Inaba monovalent serum for Vibrio cholerae for slide agglutination test, and those agglutinated with Ogawa monovalent serum for Vibrio cholerae and not agglutinated with Inaba monovalent serum for Vibrio cholerae are Ogawa, and vise versa. Those agglutinated obviously with two monovalent sera are Hikojima.

13) Result determination: Agglutinated with diagnostic serum for specificity of O1 or O139 Vibrio cholerae colonies, no self-solidifying in normal saline, positive in the oxidase test, positive in the mucous thread test, positive in dynamic, Gram-negative short and slight campylobacter and sporeless. It may be reported that O1 or O139 Vibrio cholerae colonies are detected. After further test of O1 Vibrio cholerae colony with Ogawa and Inaba monovalent sera, it is reported that Ogawa

serotype, Inaba serotype or Hikojima serotype of O1 Vibrio cholerae colony is detected.

2.2.2 Plankton test method

a) 10 - 50μm plankton counting method

1) Sampling: Sample volume is 1L.
2) Shake the water sample completely, draw about 5ml and add to the 10ml centrifuge tube, add an appropriate amount of CMFDA solution, mix completely and place it at the room temperature for 30-60min straining at a darkroom.
3) Add an appropriate amount of Lugol's reagent into the remaining water sample for long-time storage.
4) After staining is completed, add an appropriate amount of formaldehyde -fixed sample.
5) Draw 1ml sample and add to 1ml algae counting plate, cover the coverslip, observe under the fluorescence microscope upon the blue light excitation, and count the algae emitting green fluorescence.
6) In order to ensure the confidence level of counting results, increase the times of counting in case that there are fewer surviving individuals in the sample.
7) Record the experimental data, calculate the concentration of plankton that can survive, and the result is represented by

"ind/ml".

b) Detection method for plankton greater than 50μm

1）Sampling and enrichment: Use 37μm filter screen to filter 1,000L water body, and collect the plankton in a 1L sample bottle. Store it at 4 ℃ in shade.

2）Raw water enrichment counting: Add an appropriate amount of formaldehyde solution for fixation before sample counting, and identify the sample counting under the stereomicroscope. If the number of samples is large (>1,000), pick out the large crustaceans, arrow worms, etc. for counting, and use the zooplankton riffle sampler to separate the remaining samples to identify, count and convert the number of zooplankton (ind/m^3).

3）Other samples counting: Add neutral red solution based on 0.1% of the sample volume, stain for 15min, and identify and count under the stereomicroscope. For counting, observe if the individuals of zooplankton in the sample are complete in morphology, use the probe to stimulate the red individual with complete morphology, and if it responds to the stimulation, then record it as a living organism. All samples shall be stored at the temperature of 4℃ prior to testing, and completed the detection within 24 hours. After the detection, add formaldehyde solution in the proportion of 5% of sample volume so as to maintain the samples for a long period.

4）Quantity calculating of plankton

C=N/V

Among which, C - total specimens of per unit volume in seawater; ind/m^3

N - the number of the whole net; ind

V - water filtration capacity; m^3

2.2.3 Test method of water quality index

a) Water temperature

Use mercury thermometer for determination as per *Water and Wastewater Monitoring and Analysis Method (4th Edition)*. Insert directly the mercury thermometer into water sample for measurement, and read after the reading of tested water temperature is constant.

b) Dissolved oxygen (DO)

Use HACH.Sension8 dissolved oxygen meter for determination as per *Water and Wastewater Monitoring and Analysis Method (4th Edition)*.

The test is subject to the following operational procedures:

1）Use deionized water to rinse dissolved oxygen electrode;

2）Press “Start” to start dissolved oxygen meter;

3）Insert the cleaned electrode into the water sample to be tested;

4）Press READ to start reading and record the results after the display is stable.

c) Turbidity

Use HACH. (4650000) 2100P portable turbidimeter for determination as per *Water and Wastewater Monitoring and Analysis Method (4th Edition)*.

The test is subject to the following operational procedures:

1) Inject water sample to the sample cell until it reaches the mark, about 15ml;

2）Use a piece of special cloth to wipe the water traces and fingerprints on outer surface of the sample;

3）Use a piece of special cloth to apply a layer of silicone oil to the outer surface of the sample cell;

4）Press I/O to start the instrument;

5）Align the sample cell with the mark in the front of the sample tank following the direction of arrow;

6）Press READ to start reading and record the result.

d) PH and redox potential

Use HACH.sension156 portable multi-parameter tester+5191000 pH electrode for determination as per *Water and Wastewater Monitoring and Analysis Method (4th Edition)*.

The test is subject to the following operational procedures:

1）Use deionized water to rinse pH electrode;

2）Press “Start” to start the multi- parameter tester;

3）Insert the cleaned electrode into the water sample to be tested;

4）Press READ to start reading and record the results after the reading is stable;

5）Press pH/mv to switch to the redox potential index, and record the results after the reading is stable.

e) Salinity

Use HACH.sension156 portable multi-parameter tester+5197500 conductivity electrode for determination as per *Water and Wastewater Monitoring and Analysis Method (4th Edition)*.

The test is subject to the following operational procedures:

1）Use deionized water to rinse conductivity electrode;

2）Press “Start” to start the multi- parameter tester;

3）Insert the cleaned electrode into the water sample to be tested;

4）Press READ to start reading and record the salinity determination results after the display is stable.

5）Press con/TDS/sal to switch to TDS index, and record the results until the reading is stable;

6）Press con/TDS/sal to switch to sal indicator, and record the results until the reading is stable.

f) TSS

Use the gravimetric method for the determination of TSS according to GB 17378 [1] .4-1998 *The Specification for Marine Monitoring-Part 4:*

Seawater Analysis.

The test is subject to the following operational procedures:

1）Heat and boil the 0.45 μ m microporous membrane to be used at the water bath with a constant temperature of 75 ℃ for 4h, use flat toothless tweezers to place the microporous membrane in a weighing bottle, transfer into a baking oven to bake at 45℃ for 8h, take out and place in a drier for 8h cooling, and weigh;

2）Assemble the filtration system, place correctly the microporous membrane with a constant weight on the membrane tray of the membrane filter, use deionized water to wet the membrane, suck and filter, cover the supporting funnel, and use clamp to fix;

3）Collect three parallel samples at each sampling point, and shake completely 1L water sample;

4）Start the vacuum pump and engage the switch to pour the water sample into the filter, use about 50ml deionized water to wash the 1L constant volume sampler, and pour into the filter. In order to wash off the salt, use after pumping empty deionized water to drip wash the filter wall and suspended matters twice, about 50ml for each, and pump empty again;

5）Place the membrane in the constant temperature drying oven, set the temperature to 45℃, dehydrate at a constant temperature for 8h, take out and put in the desiccator, and weigh it after cooling for 8h;

6）Weighing: Select a balance with 0.0001 accuracy to weigh quickly, record environmental parameters during the weighing, and the temperature and humidity of testing room should be basically consistent;

7）Calculate the test results

g) DOC and POC

Use Shimadzu TOC-VCPH total organic carbon analyzer for determination of DOC and POC as per *Water and Wastewater Monitoring and Analysis Method (4th Edition)*. TOC-VCPH analyzer uses catalytic combustion-non-dispersive infrared gas analysis; the sample injection volume is 10μl-2,000μl and the combustion temperature is 680 ℃; the optimum operating conditions can be automatically set and the optimum operating curve can be automatically selected.

The test is subject to the following operational procedures:

1）After sample collection, use sealing film to seal, and place in a 4 ℃ refrigerator for keeping. Analyze and determine within 24h under laboratory conditions. Quality assurance and control in the entire analysis process are subject to *Technical Specifications Requirements for Monitoring of Surface Water and Waste Water (HJ/T91-2002)* and *Environmental Monitoring of Water Quality Assurance Manual*.

2）Prepare organic carbon standard stock solution and inorganic carbon standard stock solution, and the instrument will automatically dilute the standard stock solution to standard series for determination of

standard sample and draw TC and IC calibration curves.

3) Quantify and inject the water sample into the TC and TIC reaction tubes, determine TC and TIC at their respective operating conditions, and then calculate the measured value of TOC.

4）Filter an appropriate volume of water sample through a 0.45μm mixed-fiber membrane. Repeat step 3) to treat the filtered water sample, and then obtain the measured difference of DOC.

5) For the same water sample, the particulate organic carbon POC=TOC-DOC

2.3 Test instrument

Basic laboratory and test equipment and facilities include but are not limited to: Biological microscope, thermometer, pH meter, salinity meter and turbidimeter; in addition, the equipments or instruments that can test online flow, temperature, pressure and other parameters are also provided.

Basic instruments needed for ship test are shown in Table 2-2.

Table 2-2 List of test instruments

Instrument name	**Manufacturer**	**Type**
Portable turbidity meter	HACH	2100P
Dissolved oxygen meter	HACH	Sension8
Electrochemical analyzer + Ph electrode + CD electrode	HACH	HQ40D
Residual chlorine meter	HACH	Sension8

TOC determinator	Shimadzu	TOC-VCPH
Fluorescence biological microscope	Olympus	BX51
Biological microscope	Motic	B1
Inverted biological microscope	Jiangnan Novel	DX-202
Refrigerator	Haier	BCD-539WF
Portable bacteriological incubator	Beijing Zhongxing	101-0AB
Stereoscopic microscope	Shanghai Optical	XTZ-D
Phytoplankton counting plate	Sedgewick Rafter	1ml
Zooplankton sample divider	Hydro-bios	Folsom
Zooplankton counting chamber	Hydro-bios	70ml
Utermöhl plankton settler	Hydro-bios	10ml、50ml
Pipette	Thermo	1-1000μl
Petri dish	Shuniu	9cm
Test tube	Shuniu	15*150
Measuring cylinder	Shuniu	50，100，200ml
Beaker	Shuniu	500，1000，2000ml

3 Onboard test requirements

3.1 Test principle

Onboard test is subject to G8, adopts control test, uses raw water for test in compliance with certain biological standards and determines the treatment effect of the system by sampling test. Use applicable test methods for the sample analysis results to get scientific conclusions on the system's biological effectiveness and make estimates on test errors.

3.2 Test of ballast water treatment capacity

In this test, the system's rated capacity of treatment is 600m^3/h.

3.3 Installation of test system

Ballast water management system is installed by the professionals of the manufacturer and R&D institutions (COSCO Group and Tsinghua University) in accordance with the *Blue Ocean Shield Ballast Water Management System Operation and Maintenance Manual* (O&M manual); it makes changes as small as possible in order to adapt to the test facility, and will not have any impact on the process.

After installation is completed, the system manufacturer / R&D institutions (COSCO Group and Tsinghua University) calibrate the ballast water management system and its related monitoring equipment

according to the procedures and methods provided in O&M manual. In the installation phase, the monitoring equipment for the test facility (for online testing of temperature, flow, pressure and other parameters) is put in place, and the suppliers (COSCO Group and Tsinghua University) calibrate the test facility.

3.4 Test water requirements

The water for onboard test is natural water without adding any artificial ingredients. Raw water for test of biological effectiveness should meet in terms of biological composition the following requirements:

Table 3 - 1 Biological composition requirements of raw water

Category/size	Density
Plankton≥ 50μm	$>10^2$ ind/m^3
Plankton between 10-50μm	$>10^2$ ind / ml

3.5 Test cycle

Test cycle of onboard ship is to verify biological effectiveness, and the biological effectiveness cycle must use the raw water in line with the inflow water requirements in G8.

3.5.1 Number of test cycle

In order to distinguish test cycles, it is necessary to give standard

numbers to the test cycles. Test cycle number is represented by Roman numerals and marked after the equipment name, for example: "BOS02-Ⅲ-" represents the 3rd test cycle of the onboard test.

3.5.2 Composition of test cycle

A test cycle in this project includes: Load ballast water onboard; store the ballast water onboard; the ballast water management system treats the ballast water other than that in the control tank; and discharge the ballast water onboard.

3.5.3 Rated capacity of treatment

The rated capacity of treatment of ballast water management system in the onboard test is 600m^3/h, and the flow of inflow water should also be 600m^3/h.

3.5.4 Number of test cycles

Complete at least 3 consecutive effective test cycles according to G8, and discharge the treated ballast water according to D-2. Any ineffective test cycle will not affect the coherence, and test cycles including ineffective and unsuccessful tests should not be less than 6 months.

According to 2.2.2.5 in G8, an effective test cycle is that at the filling of ballast water, the concentrations of survivable organisms in the control tank and the ballast water to be treated should be over 10 times

that in D-2.1, and that in the control tank at the discharge should be higher than that in D-2.1.

If a test cycle of treatment meets the following conditions, it may be considered a success:

1) If applicable, it should be recognized as effective in accordance with 2.2.2.5 in G8;

2) In parallel samples, the average density of survivable organisms at a minimum size equal to or larger than 50μm is less than 10 ind/ m^3;

3) In parallel samples, the average density of survivable organisms at a minimum size smaller than 50μm and equal to or larger than 10μm is less than 10 ind/ml;

4) The average density of Vibrio cholerae (O1 and O139) less than 1cfu/100ml or 1cfu/g Zooplankton sample (wet weight);

5) The average density of E. coli in the parallel samples is less than 250cfu/100ml;

6) The average density of enterococcus in the parallel samples is less than 100cfu/100ml.

3.5.5 Time span of onboard test

Test cycles including the ineffective and unsuccessful tests should not be less than 6 months.

3.6 Sampling and determination

3.6.1 Sampling principles and sampling tap schematic diagram

Sample selection should meet the conditions "representative and random, sample size appropriate, sampling method scientific and reasonable" in the guidelines in the Convention, and should also ensure:

1) Ensure the safety of operating personnel: The operating personnel should wear uniform working clothes, protective shoes and helmets, and the sampling personnel should also be equipped with disposable rubber gloves.

2) Simple, feasible and fast and can be used at the ballast water discharge points: The special sampling personnel should be responsible for sampling by use of dedicated sampling wares. Place the sampling wares cleaned at the appropriate sampling points before start of the test and place them based on the sampling time on the label. Open the sampling pipe valve to drain 1min before each sampling, and wash the inner and outer walls of the sampling wares.

Sampling pipe section diagram is as follows:

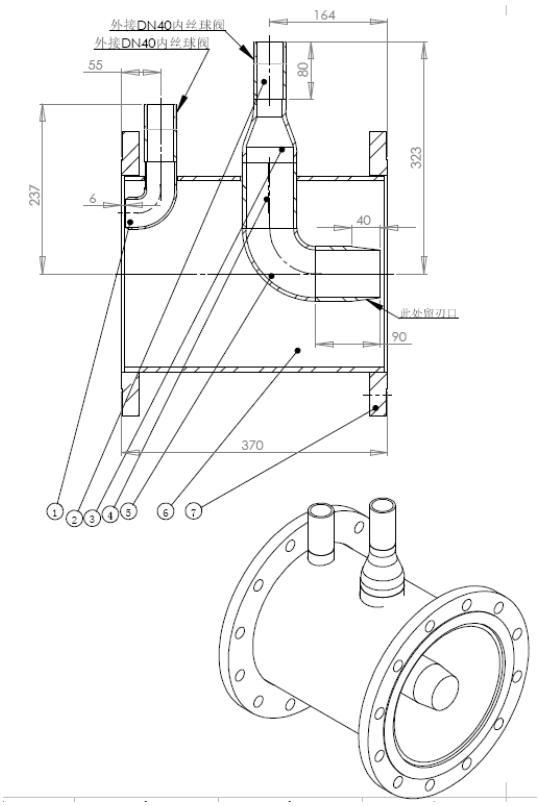

Figure 3－1 Sampling pipe section diagram

In order to facilitate the installation to the straight pipe section of ballast pipe, the sampling pipe section is connected by use of flange connection method, and the sampling pipe opening faces the incoming direction of main water flow in the pipe. Chamfered edges, and the sampling pipe uses 1.5-fold inner isokinetic diameter design.

Isokinetic diameter equation:

$$Diso = Dm\sqrt{Qiso / Qm}$$

The flow of main pipe is 600m^3/h, the diameter of main pipe is 250mm, the sampling flow is 12m^3/h, the calculated isokinetic diameter is 35mm, and the actual design diameter is around 58mm.

The sampling pipe section in design has a return pipe that is used to re-inject the filtered solution after enrichment of water samples onboard

to the pipes.

3.6.2 Introduction of sampler and enrichment net

Functions:

- Take test water from the pipe, and pump automatically the residual enrichment residual liquid to the water point. Maintain the water intaking rate stable and the sampling flow rate constant.
- Sampling flow: $12m^3$
- Power supply: AC440V 60Hz
- Pump lift: 50m
- Power: 3 kW
- System construction:

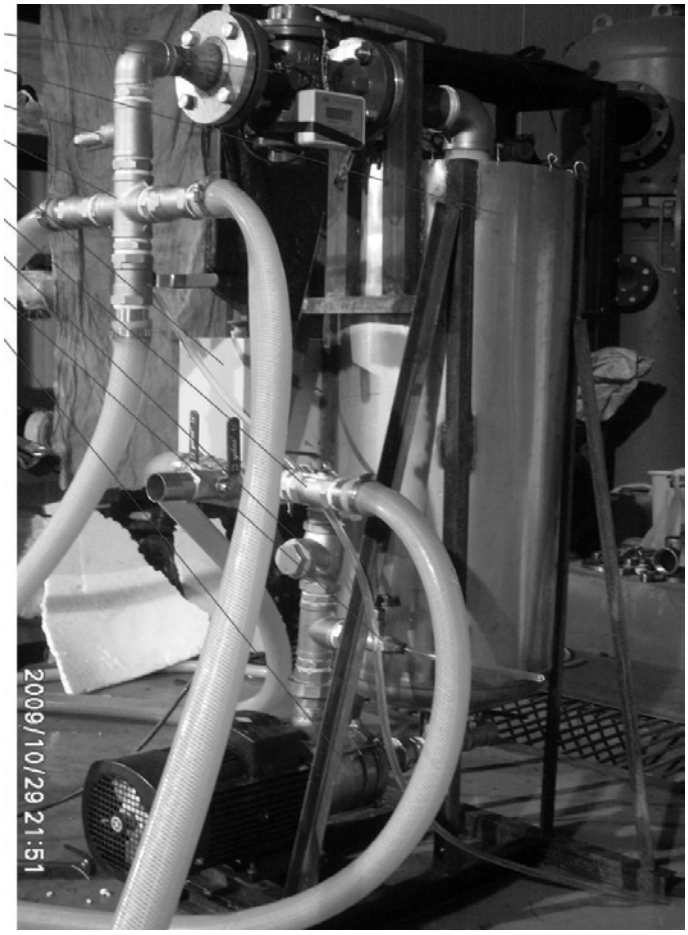

Figure 3－2 Sampler appearance

Application method:

- Adjust the flow balancing valve to the target flow
- Connect the working power and control power
- Open return valve
- Hang filter screen
- Open intake valve
- Complete sampling
- Turn off water intaking valve
- lose back-water valve after auto-stop of pump
- Inject fresh water from the sample opening, clean the sampler, and

drain the residual liquid in barrel

- Cut off breaker

Installation:

- Shipment of sampler body
- After the sampler body is in place, use DN40 hose to connect the sampler to the intake at the sampling point, and backwater inlet to the sampler
- Connect AC440V60Hz working power to three-phase breaker, and be sure the rotation of motor for test is right
- Connect AC220V control power to two-phase breaker

Notes:

- Sampling barrel discharge. Fault cause: Lower output pressure in case of presence of air in the pump body. The air will be exhausted with the air bubbles under normal circumstances, and the pump pressure will immediately rise. But when too much air is present in the pump and the outlet pressure is too low to open the check valve, the air in the pump will not be discharged, causing backflow stop. Solutions: Open filtered liquid collection valve and discharge the air. Pump pressure recovers after rise.
- Falling objects in the barrel. Objects larger than 5mm falling in the barrel will not affect the normal operation of the system. Press emergency stop button to stop the pump if necessary. When

emergency stop state is eliminated, the system will continue the logic state before emergency stop.

- Control relay to forcibly start the pump.

Enrichment nets of plankton:

When zooplankton samples are collected, they should be subject to enrichment due to the large sample size during the sampling. Install enrichment net on the sampler to realize on-line enrichment.

Parameters of the enrichment net are as follows:

Table 3 - 2 Parameters of enrichment net

Material	Aperture	Profile	Base circle diameter	Height
Monofilament nylon	37μm	Cone	45cm	55cm

3.6.3 Sampling points and time

According to G8, this test has four sampling points. For the convenience of quote, the capital English letters are used to name each sampling point.

For A and B, after the test cycle begins, sample from them at the beginning, middle time and nearly end of loading ballast water stage; for C and D, when discharging ballast water, sample from them at the beginning, middle time and nearly end of the discharge stage. The description of the number of each sampling point is as follows:

A: The control tank is being filled with water at the filling of

ballast water;

B: The equipment is discharging water at the filling of ballast water;

C: The ballast tank is discharging water at the de-ballasting;

D: The control tank is discharging water at the de-ballasting;

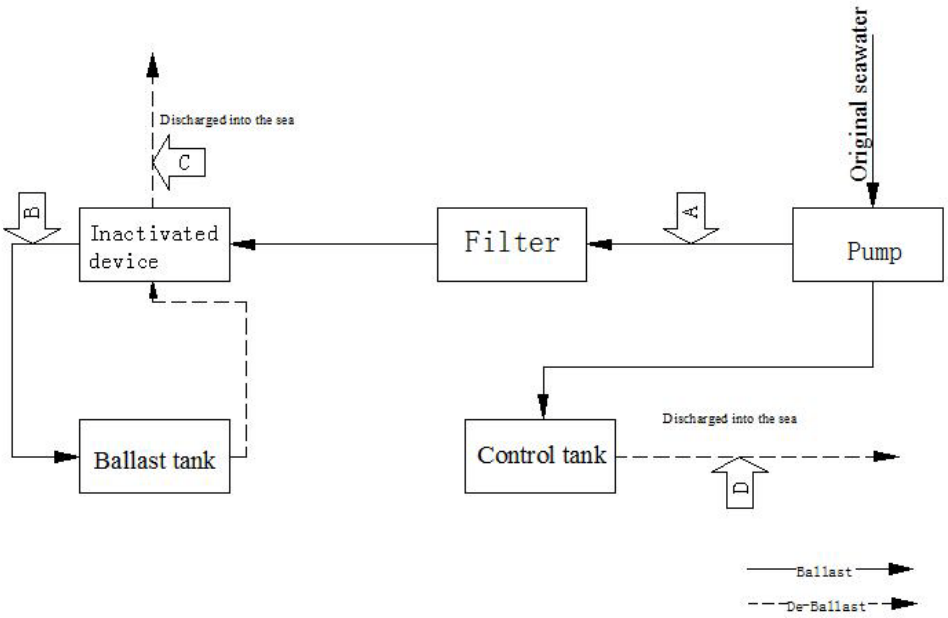

Figure 3－4　Schematic diagram of the sampling points

3.6.4 Sample volume

The required sample pieces and sample amount depend on sampling purposes and specific analytical methods. During the test, sampling should be done respectively for the following cases:

1) Organisms with the minimum size greater than or equal to 50μm;

2) Organisms with the minimum size greater than or equal to 10μm but smaller than 50μm;

3) E. coli, Enterococcus and Vibrio cholerae;

In each test cycle (including processing cycle and control cycle), the sample amount at each required sampling points is as shown in the following table

Table 3 – 3 Sample volume at each sampling point

Serial No.	Category/size	A	B	C	D
α	Organisms greater than or equal to 50μm	$1m^3$ *3	$1m^3$*3*3	$1m^3$*3*3	1m*3
β	Organisms smaller than 50μm but greater than 10μm	1L*3	1L*3*3	1L*3*3	1L*3
γ	E. coli, etc.	500ml*1	500ml*1	500ml*1	——
ε	Temperature, salinity and other water quality indicators	10L	——	——	——

3.6.5 Sample numbering rules

In order to distinguish between samples, it is necessary to make a standard numbering for the samples. Zone bit codes are used for the sample numbers. The form is “BOS02—test cycle number—target organisms identifications—sampling points identifications—sampling time period—natural serial number”.

Table 3 - 4 Sample numbering rules

Signification	Type	Naming method
Name of test equipment	Letters and numbers	BOS02
Testing No.	Roman numerals	Ⅰ, Ⅱ, Ⅲ……
Target organism identification	Lowercase Greek letter	Plankton≥ 50μm α Organisms between

		10μm-50μm β E. coli, etc. γ Water quality index testing ε
Sampling point identification	Capital English letters	A，B，C，D，
Sampling phase	Roman numerals	Initial phase Ⅰ Intermediate phase Ⅱ Close to closure phase Ⅲ
Natural serial number	Arabic numerals	The first repeated sample of some phase 1 The second sample of some phase 2 ……

For example, the test cycle of the sample named "BOS02-III-α-A-III-1"means: In the processing cycle of the third cycle in the onboard test, for the organisms above 50μm, the first sample taken from water inlet A at the nearly end of stage of the test cycle.

3.6.6 Instructions of sample treatment and submission for test

After sample collection, the sample should be treated according to different test items required:

1) Temperature, pH, dissolved oxygen, turbidity and other water quality parameters are required for determination by use of thermometer, pH meter, dissolved oxygen meter, turbidimeter and other instruments at the site of onboard test.
2) The water samples required for measurement of particulate organic carbon (POC), dissolved organic carbon (DOC), and total suspended solids (TSS) are required to be sent to Beijing

PONY Testing Center for test, and the samples after treatment subject to Table 3-5 should be sent to Beijing PONY Testing Center within the storage life.

3) Since the water samples required for test of plankton and bacteria can be stored for a short time, the testing organization assigns qualified testers to the wharf to build a temporary laboratory in order to ensure the effectiveness of test, and the samples collected should be sent immediately to the this laboratory. The testing organization provides quality assurance for the instruments and drugs used in this laboratory.

4) For onboard test at the wharf in Shenzhen, send part of water samples for test of bacteria to Shenzhen Inspection and Quarantine Bureau for test of Vibrio cholerae. This institution has CNAS certificate, whose test items include Vibrio cholerae.

Table 3 - 5 Instructions of sample treatment and submission for test

Test index	**Reference standards**	**Sampling volume**	**Sample container**	**Preservation conditions**	**Preservable time**
Phytoplankton	ASTM D 4137-82 Standard Practice forPreserving Phytoplankton Samples	1L	1L plastic bottle	4 ℃ shading cold preservation	24h
Zooplankton	ASTM E 1200-87 Practice forPreserving Zooplankton Samples	1t (adopting filter screen with aperture of 37 micron for enrichment)	1L plastic bottle	4 ℃ shading cold preservation	72h

Bacteria	ISO19458-2006 Water quality —— Samplingfor microbiological analysis	500ml	Sterile sampling bottle	4 ℃ shading cold preservation	18h
POC.DOC	ISO5677-3-2003Guidance on the preservation and handling of water samples	250ml	Plastic bottle	Add sulfuric acid to adjust pH ≤ 2, and keep refrigerated at 4℃ in the dark	7 d
Temperature, salinity etc.	ISO5677-3-2003Guidance on the preservation and handling of water samples	10L	Plastic bottles	Real-time measurement	
TSS	*Water and Wastewater Monitoring and Analysis Method* of the Ministry of Environmental Protection of the People's Republic of China	1L	Plastic bottles	4 ℃ shading cold preservation	7 d

3.6.7 Sample transportation

a) Transportation containers

The selection of transportation containers must meet the following principles:

1) Hermetic: Any transportation containers should not have any holes or gaps in order to avoid product contamination due to external factors, such as the entry of rain, dust and insects into the containers. All vent holes of vehicles need to be sufficiently protected.

2) Clean: Greasy dirt, sundries and rubbish which can pollute the products are not allowed in the transportation containers. Coating dropping or rusted surface on the inner walls of the containers as well as peculiar smell in the containers is not allowed.

3) Secure: Any sharp protrusion on the surface of the transportation containers, such as screws and welding slag, is not allowed.

b) Quality control for sample transportation

Sample packaging: Water samples should be kept at a low temperature; the sampling bottles should be separated by foam sheets around and covered with crushed ice; insulation foam box should be provided outside and sealed with adhesive tape, which should be labeled by the personnel with the CCS Seals after check; the samples should be uniformly placed in the foam packing container to avoid easy damage due to different weights and the container should be provided with thermometer for reading; the sample packing personnel need to wear safety gloves for packing work.

Sample loading: Unauthorized persons are not allowed to stay during sample handling process. The handling is done in accordance with unified command. Since sampling bottles are fragile, they should be handled with care, to avoid violent shaking, bump and upside down; when the products are stacked, the front side is up in accordance with the arrow marks on the sample transportation cases.

During the sample transportation: The personnel in charge of the sample transportation should keep to the post, check and supervise the transportation. Handling personnel should transport, handle in accordance with quality standards and grasp the situations at any time. During transportation, check carefully the samples at the fixed point on a regular basis and take measures in time if any abnormality is found. Ensure that the samples are protected from rain, fire, stealing, corrosion, bumping and collision and the goods are intact after arrival at the destination.

Sample unloading: The same as sample loading Before taking off the seals of the samples, check if the temperature complies with the requirements of the test specifications, if the samples are in good conditions, and if the samples are polluted.

3.6.8 Requirements of qualified judgment of samples and data

Witnessed by competent authorities of sampling and CCS, both the samples and data meet the relevant requirements of QAPP. The qualification of test equipment depends on its compliance with the requirements of 3.5.4.

3.7 Records during the test

3.7.1 Equipment operation state records

For all test cycles, the performance of ballast water management system should be monitored, including, but not limited to the following aspects:

1) Time: Record the time of startup, shutdown, operation, maintenance etc. of ballast water management system. If the equipment is equipped with the monitoring device similar to "black box", the time will be automatically recorded as the reference for other parameter monitoring results.

2) Flow velocity and pressure: During the test cycles, such parameters as important pipelines of ballast water management system, water flow velocity of equipments and pressure are recorded.

3) Residues: Such parameters as the quantity, generation rate and concentration of the residues generated in the test cycles are recorded.

4) Energy consumption: Record the ballast water management system's energy consumption parameter in Kw/m^3 (water); in addition, record the peak load at the start.

5) Other energy consumption: The wastage situations of other main consumables, such as filter elements, are recorded.

6) Fault: The faults occurring in the test process should be recorded completely and accurately. The original data should be recorded for the samples obtained in the cycles which have faults. But the data should not be used for the statistical analysis of biological effectiveness of ballast water management system.

3.7.2 Recording requirements

Ballast water management system is equipped with monitoring devices which can automatically record, store, display and print useful system parameters. When manual recording is required, use a pen containing persistent ink to record in the pre-prepared data form, as shown in Table 3-6.

Table 3 - 6 Performance monitoring records for the mechanical and electrical parts

Date: Recorded by:

Test cycle number:

Startup initial time		Startup success time	
Average pressure (Pa)			
Average flow velocity (m^3/h)		Total treatment capacity (m^3)	
Total energy consumption (kWh)		Peak load (kW)	
Whether to replace filter element and the quantity replaced			
Faults and processing			

4 Description of onboard test

4.1 Preparation

During testing preparation, complete or confirm the items hereunder:

1) Confirm water resources, energy resources and others meet test requirements;
2) After ballast water management system is installed on the ships, the equipments shall be debugged and calibrated;
3) Monitoring equipments used for on-line monitoring of system performances should be placed in positions at the installation stage, and calibrated;
4) Prepare enough sampling tanks with enough volume, disinfect and dry them;
5) Prepare preliminary instruments and equipments used for determining water sample parameters; assign assay personnel who are skilled in water sample measuring;
6) Set out disposal plans for emergency cases (For emergency plans, see 4.6) to maximally protect personal health and environment;
7) Set out appropriate Quality Assurance Project Plan (QAPP).

4.1.1 Investigation on water quality of the ports

In order to facilitate selection of an appropriate port during the

onboard test, it is necessary investigate the water quality of domestic and foreign main ports. The main water quality parameters are temperature, salinity and TSS of seawater and composition of plankton in the seawater.

4.1.2 Sailing schedule query and test time arrangements

Determine sailing schedule of ship for onboard test, and select the appropriate test place and time by reference to the water quality of the ports and develop a test plan in advance.

4.2 Test flow

After onboard test outline is determined, apply for witnessing the whole process of onboard test with the CCS. The CCS staff witness and determine the preparation for the test is ready before start of the test cycle; In the whole process of test cycle, CCS staff supervise the test process, determine the test, sampling and other operations comply with G8 and other requirements; after sampling, CCS staff seal the samples to be sent to the testing organization and ensure that the samples' seals are intact at the receipt of such samples.

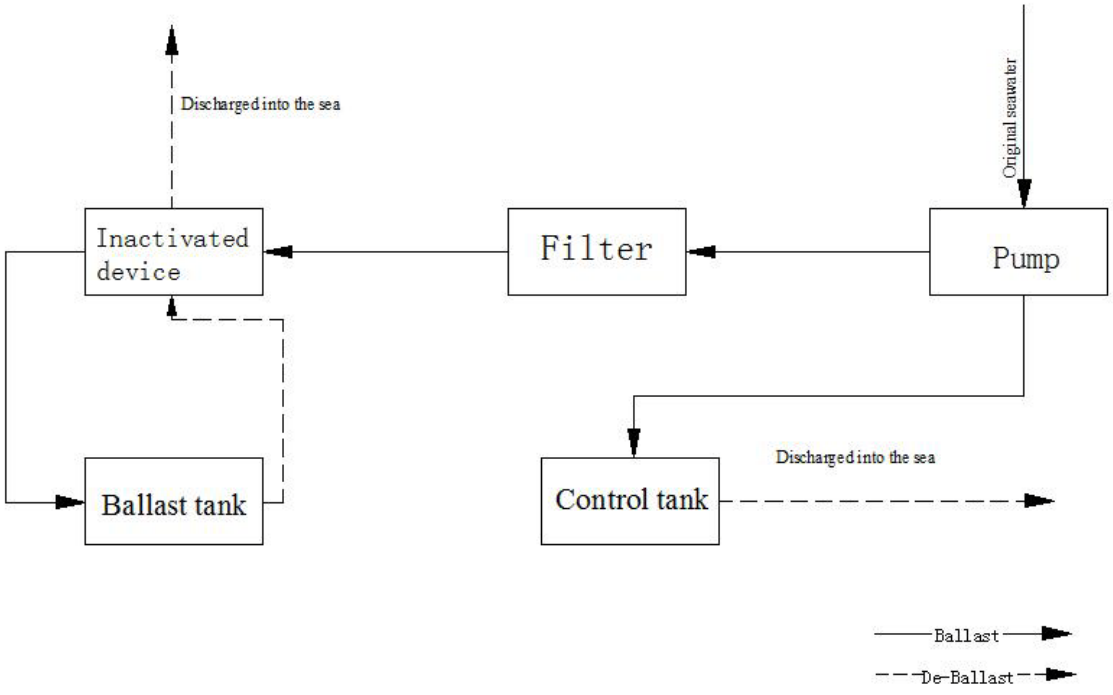

Figure 4－1Test flow schematic diagram

4.2.1 Selection of ballast tanks and control tanks

BOS ballast water management system is installed on COSCO ROTTERDAM that is a 5250TEU container ship with the total ballast water volume of 15329.4m^3. Because the ballast tank and control tank selected in the testing process need emptying, two 1074.3m^3 ballast tanks were used as the ballast tank and control tank for obtaining evidence during the onboard test. The right double bottom tank No5.D.B.W.B.T (S) was used as ballast tank for onboard test and No5.D.B.W.B.T. (P) as control tank for onboard test. No3.DBWBT was used as access chamber for flushing ballast pipelines.

WATER BALLAST TANKS			* S.G. = 1.025			
TANK NAME	LOCATION (FR.NO.)	CAPACITY 100 % FULL (m3)	* WEIGHT 100 % FULL (t)	L.C.G. FROM MIDSHIP (m)	V.C.G. ABOVE B.L. (m)	MAX.I (m4)
FORE PEAK TANK (C)	304.0 - 335.4	714.1	732	-127.57	8.00	108
NO.1 D.B.W.B.T. (C)	249.0 - 304.0	1,456.4	1,493	-95.95	3.48	4,516
NO.2 D.B.W.B.T. (P)	215.0 - 249.0	596.5	611	-58.40	2.57	1,498
NO.2 D.B.W.B.T. (S)	215.0 - 249.0	596.5	611	-58.40	2.57	1,498
NO.3 D.B.W.B.T. (P)	181.0 - 215.0	841.2	862	-29.47	2.17	3,052
NO.3 D.B.W.B.T. (S)	181.0 - 215.0	841.2	862	-29.47	2.17	3,052
NO.4 D.B.W.B.T. (P)	147.0 - 181.0	1,018.4	1,044	-0.99	1.56	9,739
NO.4 D.B.W.B.T. (S)	147.0 - 181.0	1,018.4	1,044	-0.99	1.56	9,739
NO.5 D.B.W.B.T. (P)	113.0 - 147.0	1,074.3	1,101	26.55	1.51	11,291
NO.5 D.B.W.B.T. (S)	113.0 - 147.0	1,074.3	1,101	26.55	1.51	11,291
NO.1 S.W.B.T. (P)	147.0 - 181.0	789.7	809	-2.07	11.53	94
NO.1 S.W.B.T. (S)	147.0 - 181.0	789.7	809	-2.07	11.53	94
NO.2 S.W.B.T. (P)	77.0 - 113.0	1,924.5	1,973	56.63	6.19	3,802
NO.2 S.W.B.T. (S)	77.0 - 113.0	1,924.5	1,973	56.63	6.19	3,802
AFT PEAK TANK (C)	3.0 - 22.0	669.7	686	123.31	13.56	9,153
T O T A L		15,329.4	15,711	(0.14)	(4.89)	72,729

Figure 4－2Ballast tank information table

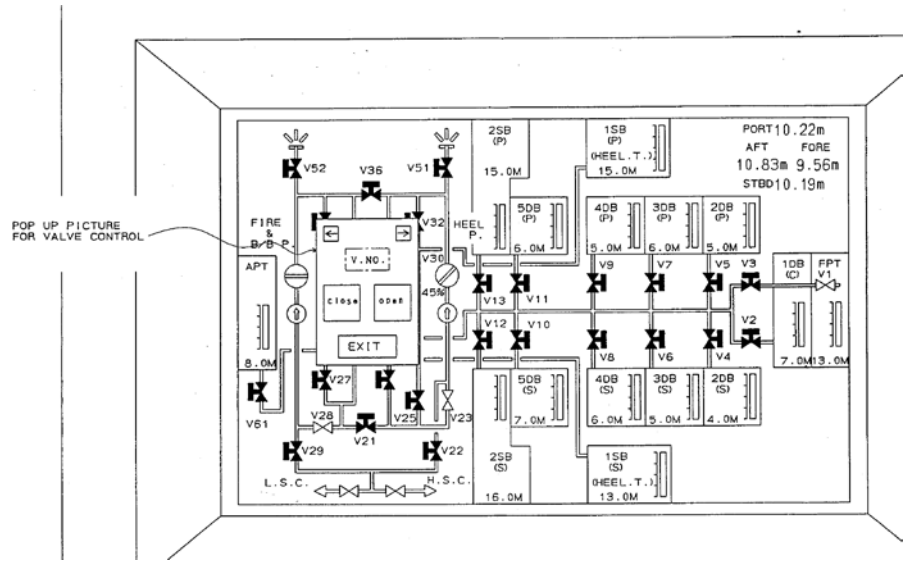

Figure 4－3　Distribution diagram of control tank and ballast tank

4.2.2 Ballast water filling processes

1 List of items prepared for test:

1. 1L sampling bottle: 26 pieces;
2. 500ml glass bottle: 4 pieces;

3. 12 enrichment nets;
4. 10 pairs of rubber gloves;
5. 1 recorder and 1 camera;
6. 4 intercoms;
7. 20L barrel for collecting filtered water: 2 pieces;
8. Washing net and washing bottle: 2 pieces;
9. 2 Mark pens;
10. Notebook computer: 2 sets

2 Preparation work on Day -1:

1) Preparation of sampling bottle:

Clean plastic sampling bottle, and sterilize sampling bottle of bacteria; after sampling bottle is ready, label it; taking the first test cycle for example, the sampling bottle label number is shown in the following table;

Table 4 - 1 Ballast test sampling bottle number table

Sampling bottle number	Sampling bottle type
BOS02-Ⅰ-α-B-I-1	1L plastic bottle
BOS02-Ⅰ-α- B -I-2	1L plastic bottle
BOS02-Ⅰ-α- B I-3	1L plastic bottle
BOS02-Ⅰ-α-B-II-1	1L plastic bottle
BOS02-Ⅰ-α-B-II-2	1L plastic bottle
BOS02-Ⅰ-α-B-II-3	1L plastic bottle
BOS02-Ⅰ-α-B-Ⅲ-1	1L plastic bottle
BOS02-Ⅰ-α-B-Ⅲ-2	1L plastic bottle
BOS02-Ⅰ-α-B-Ⅲ-3	1L plastic bottle
BOS02-Ⅰ-α-A-I-1	1L plastic bottle
BOS02-Ⅰ-α-A-II-1	1L plastic bottle
BOS02-Ⅰ-α-A-Ⅲ-1	1L plastic bottle
BOS02- I -β-B-I-1	1L plastic bottle

BOS02- I -β- B -I-2	1L plastic bottle
BOS02- I -β- B I-3	1L plastic bottle
BOS02- I -β-B-II-1	1L plastic bottle
BOS02- I -β-B-II-2	1L plastic bottle
BOS02- I -β-B-II-3	1L plastic bottle
BOS02- I -β-B-Ⅲ-1	1L plastic bottle
BOS02- I -β-B-Ⅲ-2	1L plastic bottle
BOS02- I -β-B-Ⅲ-3	1L plastic bottle
BOS02- I -β-A-I-1	1L plastic bottle
BOS02- I -β-A-II-1	1L plastic bottle
BOS02- I -β-A-Ⅲ-1	1L plastic bottle
BOS02- I -γ-A-II-1	500ml glass bottle
BOS02- I -γ-A-II-1	500ml glass bottle
BOS02- I -γ-B-II-1	500ml glass bottle
BOS02- I -γ-B-II-1	500ml glass bottle
BOS02- I -ε-A-II-1	1L plastic bottle
BOS02- I -ε-A-II-1	1L plastic bottle
BOS02- I -ε-A-II-1	10L plastic sampling barrel

2) Confirm 12 enrichment nets are prepared and mark them, as shown in the table below;

Table 4 - 2 Ballast test enrichment net number table

Enrichment net number	**Enriched water volume**
BOS02-Ⅰ-α-B-I-1	1t
BOS02-Ⅰ-α- B -I-2	1t
BOS02-Ⅰ-α- B I-3	1t
BOS02-Ⅰ-α-B-II-1	1t
BOS02-Ⅰ-α-B-II-2	1t
BOS02-Ⅰ-α-B-II-3	1t
BOS02-Ⅰ-α-B-Ⅲ-1	1t
BOS02-Ⅰ-α-B-Ⅲ-2	1t
BOS02-Ⅰ-α-B-Ⅲ-3	1t
BOS02-Ⅰ-α-A-I-1	1t
BOS02-Ⅰ-α-A-II-1	1t
BOS02-Ⅰ-α-A-Ⅲ-1	1t

3 Day 0 test procedure:

Table 4 - 3 Ballast test process

Time (min)	Operation	Responsible person
－30:00	Place sampling bottle at the site	
－10:00	Videorecord	
－10:00	Check helmets, assign tasks, and distribute intercoms and gloves	
－6:00	Start computer records	
－5:00	Set onboard valves to ballast double bottom tank No.4 (access chamber)	
－5:00	Set equipment valves to passing through filter and UV and manual mode	
0:00	Start pump ($600m^3/h$)	
0:00	Open outlet and inlet of sampler, do not hang nets, and wash sampling pipelines	
02:00	Switch to ballast tank (right tank of double bottom tank No.5)	
02:00	Adjust manually the opening of electric valve at UV outlet to back pressure 1.6Bar	
03:00	Take samples at B point, a total of 9 1t water samples. Record accumulative flow when hanging net; change net after the cumulative flow is increased by 1; use sampling bottle with the same number β as the sampling net during sampling to take 1L water.	
03:00-50:00	Start manual backwashing when the differential pressure of filter is more than 3kg	
27:00	Monitor if it is taken to the sample with tail number II－2	
28:00	Take 500ml BOS02-I-γ-B-II	
57:00	Switch valve to control tank (left double bottom tank No. 5)	
58:00	Set equipment valves to passing through filter bypass, UV off, and manual mode, and start manual backwashing	

58:00	Adjust manually the opening of electric valve at UV outlet to back pressure 1.6Bar	
1:00:00	Take samples at A point, hang net for BOS02-I-α-A-Ⅰ-1, record accumulative flow when hanging net, stop sampling and remove net after the accumulative flow is increased by 1t, use sampling bottle with the same number β as the sampling net to take 1L water.	
1:26:00	Take samples at A point, hang net for BOS02-I-α-A-Ⅱ-1, record accumulative flow when hanging net, stop sampling and remove net after the accumulative flow is increased by 1t, use sampling bottle with the same number β as the sampling net to take 1L water. And take 500ml BOS02-I-γ-A-II water sample and 10L BOS02-I-ε-A-II water sample	
2:00:00	Take samples at A point, hang net for BOS02-I-α-A-III-1, record accumulative flow when hanging net, stop sampling and remove net after the accumulative flow is increased by 1t, use sampling bottle with the same number β as the sampling net to take 1L water.	
2:06:00	Close valve and stop pump	
2:06:00	Empty sampler	
2:06:00	Clean enrichment net	
2:30:00	Clear the site, and check sampling bottles	
2:35:00	CCS sample sealing	
2:40:00	Sample transport	

4 Enrichment flow record table

Monitor flow of flowmeter on the sampler during the test to ensure accuracy of sample volume.

Table 4 - 4 Enrichment flow record table

Enrichment net number	Initial flow
BOS02- I -α-B-I-1	
BOS02- I -α- B -I-2	
BOS02-I I -α- B -I-3	
BOS02- I -α- B -II-1	
BOS02- I -α- B -II-2	
BOS02- I -α- B -II-3	
BOS02- I -α- B -III-1	
BOS02- I -α- B -III-2	
BOS02- I -α- B -III-3	
BOS02- I -α-A-I-1	
BOS02- I -α-A-II-1	
BOS02- I -α-A-III-1	

4.2.3 Ballast water discharge test process

1. List of items prepared for test:

1. 1L sampling bottle: 24 pieces;
2. 500ml glass bottle: 2 pieces;
3. 12 enrichment nets;
4. 10 pairs of rubber gloves;
5. 1 recorder and 1 camera;
6. 4 intercoms;
7. 20L barrel for collecting filtered water: 2 pieces;
8. Washing net and washing bottle: 2 pieces;
9. 2 Mark pens;
10. Notebook computer: 2 sets

2 Preparation work on Day -1:

1) Preparation of sampling bottle: Clean sampling bottle, and

sterilize glass sampling bottle of bacteria; label after check. Taking the first test cycle for example, the de-ballast test sampling bottle numbers are shown in Table 3-10.

Table 4 - 5 De-ballast test sampling bottle number

Sampling bottle number	Sampling bottle type
BOS02-Ⅰ-α-C-I-1	1L plastic bottle
BOS02-Ⅰ-α- C -I-2	1L plastic bottle
BOS02-Ⅰ-α- C I-3	1L plastic bottle
BOS02-Ⅰ-α-C-II-1	1L plastic bottle
BOS02-Ⅰ-α-C-II-2	1L plastic bottle
BOS02-Ⅰ-α-C-II-3	1L plastic bottle
BOS02-Ⅰ-α-C-Ⅲ-1	1L plastic bottle
BOS02-Ⅰ-α-C-Ⅲ-2	1L plastic bottle
BOS02-Ⅰ-α-C-Ⅲ-3	1L plastic bottle
BOS02-Ⅰ-α-D-I-1	1L plastic bottle
BOS02-Ⅰ-α-D-II-1	1L plastic bottle
BOS02-Ⅰ-α-D-Ⅲ-1	1L plastic bottle
BOS02- I -β-C-I-1	1L plastic bottle
BOS02- I -β- C -I-2	1L plastic bottle
BOS02- I -β- C I-3	1L plastic bottle
BOS02- I -β-C-II-1	1L plastic bottle
BOS02- I -β-C-II-2	1L plastic bottle
BOS02- I -β-C-II-3	1L plastic bottle
BOS02- I -β-C-Ⅲ-1	1L plastic bottle
BOS02- I -β-C-Ⅲ-2	1L plastic bottle
BOS02- I -β-C-Ⅲ-3	1L plastic bottle
BOS02- I -β-D-I-1	1L plastic bottle
BOS02- I -β-D-II-1	1L plastic bottle
BOS02- I -β-D-Ⅲ-1	1L plastic bottle
BOS02- I -γ-C-II-1	500ml glass bottle
BOS02- I -γ-C-II-2	500ml glass bottle

2) Confirm 12 enrichment nets are prepared and mark numbers;

Table 4 - 6 De-ballast test enrichment net number table

Enrichment net number	**Enriched water volume required**
BOS02-Ⅰ-α-C-I-1	1t
BOS02-Ⅰ-α- C -I-2	1t
BOS02-Ⅰ-α- C I-3	1t

BOS02-Ⅰ-α-C-II-1	1t
BOS02-Ⅰ-α-C-II-2	1t
BOS02-Ⅰ-α-C-II-3	1t
BOS02-Ⅰ-α-C-Ⅲ-1	1t
BOS02-Ⅰ-α-C-Ⅲ-2	1t
BOS02-Ⅰ-α-C-Ⅲ-3	1t
BOS02-Ⅰ-α-D-I-1	1t
BOS02-Ⅰ-α-D-II-1	1t
BOS02-Ⅰ-α-D-Ⅲ-1	1t

3 Day 0 test procedure

Table 4 - 7 De-ballast test process

Time (min)	**Operation**	**Responsible person**
－30:00	Place sampling bottle at the site	
－10:00	Videorecord	
－10:00	Check helmets, assign tasks, and distribute intercoms and gloves	
－5:00	Set equipment valves to passing through filter bypass and UV, UV lamp on , and manual mode	
0:00	Set onboard valves to starting ballasting the right tank of double bottom tank No. 5 (ballast tank)	
0:00	Start pump (600m^3/h)	
0:00	Open outlet and inlet of sampler, do not hang nets, and wash sampling pipelines	
02:00	Adjust manually the opening of electric valve at UV outlet to back pressure 1.6Bar	
03:00-:57:00	Take samples at C point, hang net BOS02-Ⅰ-α-C-Ⅰ-1, record accumulative flow when hanging net; change net after the accumulative flow is increased by 1t; use sampling bottle with the same number β as the sampling net during sampling to take 1L water.	
27:00	Monitor if it is taken to the sample with tail number II－2	

28:00	Take 500ml BOS02-Ⅰ-γ-C-II	
57:00	Confirm sampling at C point is completed	
58:00	Switch valve to control tank (close valve for the right tank of double bottom tank No. 5 of the ballast tank, and open valve for the left tank of double bottom tank No. 5 of the ballast tank)	
58:00	Flush pipelines, open sampler, and do not hang net	
1:00:00	Take samples at D point, hang net for BOS02-Ⅰ-α-D-Ⅰ-1, record accumulative flow when hanging net, stop sampling and remove net after the accumulative flow is increased by 1t, use sampling bottle with the same number β as the sampling net to take 1L water.	
1:30:00	Take samples at D point, hang net for BOS02-Ⅰ-α-D-II-1, record accumulative flow when hanging net, stop sampling and remove net after the accumulative flow is increased by 1t, use sampling bottle with the same number β as the sampling net to take 1L water. Take 500ml BOS02-Ⅰ-γ-D-II	
2:00:00	Take samples at D point, hang net for BOS02-Ⅰ-α-D-III-1, record accumulative flow when hanging net, stop sampling and remove net after the accumulative flow is increased by 1t, use sampling bottle with the same number β as the sampling net to take 1L water.	
2:07:00	Close valve and stop pump	
2:07:00	Empty sampler	
2:07:00	Clean enrichment net	
2:08:00	Use residual water in the ballast tank to flush control tank (connect to the right and left banks of double bottom tank No. 5)	
3:00:00	Start pump to empty the control tank and ballast tank (connect to the right and left banks of double bottom tank No. 5)	
2:10:00	Clear the site, and check sampling bottles,	

2:40:00	CCS sample sealing	
	Sample transport	

4 Outflow water enrichment flow record table

Monitor flow of flowmeter on the sampler during the test to ensure accuracy of sample volume.

Table 4 - 8 Enrichment flow record table

Enrichment net number	Initial flow
BOS02- I -α-C-I-1	
BOS02-I-α-C-I-2	
BOS02-I-α-C-I-3	
BOS02-I-α-C-II-1	
BOS02-I-α-C-II-2	
BOS02-I-α-C-II-3	
BOS02-I-α-C-III-1	
BOS02-I-α-C-III-2	
BOS02-I-α-C-III-3	
BOS02-I-α-D-I-1	
BOS02-I-α-D-II-1	
BOS02-I-α-D-III-1	

4.3 BOS system complete machine function test operation

Test items of BOS system equipment complete machine function test include:

- Valve action test
- Fault alarm test
- Transmitter function test
- Complete machine commissioning

4.3.1 Valve action test

Use the contact screen on the BOS control system box to operate the on/off action of each valve under the manual mode, record the action execution situations of valves, and observe fault records.

Operation steps:

1. Confirm that field control air source has been connected;
2. Power on the equipment;
3. Switch the equipment to manual operation mode;
4. The valves are conducted the opening and closing operation respectively;
5. Record each valve action conditions, check equipment alarm record table, and fill in the result to Table 4-9.

Table 4 - 9 Valve action test record chart

Number	Test items	Test basis	Test results	Whether fault record appears
1	V1 startup	V1 valve color turns green on HMI	Yes□ No□	Yes□ No□
2	V1 shutoff	V1 valve color turns red on HMI	Yes □ No □	Yes □ No □
3	V2 startup	V2 valve color turns green on HMI	Yes □ No □	Yes □ No □
4	V2 shutoff	V2 valve color turns red on HMI	Yes □ No □	Yes □ No □
5	V3 startup	V3 valve color turns green on HMI	Yes □ No □	Yes □ No □
6	V3 shutoff	V3 valve color turns red on HMI	Yes □ No □	Yes □ No □
7	V4 startup	V4 valve color turns green on HMI	Yes □ No □	Yes □ No □
8	V4 shutoff	V4 valve color turns red on HMI	Yes □ No □	Yes □ No □
9	V5 startup	V5 valve color turns green on HMI	Yes □ No □	Yes □ No □
10	V5 shutoff	V5 valve color turns red on HMI	Yes □ No □	Yes □ No □
11	V6 startup	V6 valve color turns green on HMI	Yes □ No □	Yes □ No □
12	V6 shutoff	V6 valve color turns red on HMI	Yes □ No □	Yes □ No □

13	V7 startup	V7 valve color turns green on HMI	Yes □ No □	Yes □ No □
14	V7 shutoff	V7 valve color turns red on HMI	Yes □ No □	Yes □ No □
15	V8 startup	V8 valve color turns green on HMI	Yes □ No □	Yes □ No □
16	V8 shutoff	V8 valve color turns red on HMI	Yes □ No □	Yes □ No □
17	V9 startup	V9 valve color turns green on HMI	Yes □ No □	Yes □ No □
18	V9 shutoff	V9 valve color turns red on HMI	Yes □ No □	Yes □ No □
19	V10 startup	V10 valve color turns green on HMI	Yes □ No □	Yes □ No □
20	V10 shutoff	V10 valve color turns red on HMI	Yes □ No □	Yes □ No □
21	V11 startup	V11 valve color turns green on HMI	Yes □ No □	Yes □ No □
22	V11 shutoff	V11 valve color turns red on HMI	Yes □ No □	Yes □ No □
23	V12 startup	Hear the sound of V12 actuation	Yes □ No □	Yes □ No □
24	V12 shutoff	Hear the sound of V12 release actuation	Yes □ No □	Yes □ No □
25	V17 startup	V17 valve color turns green on HMI	Yes □ No □	Yes □ No □
26	V17 shutoff	V17 valve color turns red on HMI	Yes □ No □	Yes □ No □
27	V18 startup	V18 valve color turns green on HMI	Yes □ No □	Yes □ No □
28	V18 shutoff	V18 valve color turns red on HMI	Yes □ No □	Yes □ No □

4.3.2 Fault alarm test

Cut off the air supply of control gas channels, execute on/off action of pneumatic valves until fault alarm occurs, and observe fault alarm situation and fault records;

Operation steps:

1. Turn off the on-site control gas source valve;

2. Power on the equipment;

3. Switch the equipment to manual operation mode;

4. Take V1 valve as an example, on HMI, repeatedly execute the on/off action of the V1 valve until the residue compressed air in the control air channels is used up and V1 valve does not respond to the action;

5. Observe the audio-video alarm, check equipment alarm record

table and fill in the results to 4-10.

Table 4 - 10 Alarm system function test record chart

Number	Test items	Test basis	Test results	Whether fault record appears
1	Test audio-video alarm function	No pressure in air source and no action response on V1; the system will give audio-video alarm.	Yes □ No □	Yes □ No □
2	Test the alarm records	Check whether the equipment alarm record table has fault code or not: 10011 and 10012. (Meanwhile it may have fault code 10013, 10014, 10015 and 10016, not as a basis for judgment)	Yes □ No □	Yes □ No □

4.3.3 Transmitter function test

Use the POST function of the equipments to detect the faults of pressure transmitters and temperature transmitters.

Operation steps:

1. Power on the equipment;
2. Switch the equipment to manual operation mode;
3. Check equipment alarm record table and fill in the results to 4-11.

Table 4 - 11 Transmitters' functional test record table

Number	Test items	Test basis	Test results	Whether fault record appears
1	If there are faults which are automatically detected by the transmitters	Check if there are the following fault codes in the equipment alarm record table: **30001** **30002** **30003** **30011** **30012** **30021** **30022** **30031** **30032** **30041** **30042** **30051** **30061** **30062** **30071** **30072**	Yes □ No □ Fault code.	Yes □ No □

4.3.4 Complete machine commissioning

Run the complete machine of equipment under the automatic operation mode, accomplish ballast and de-ballast operation, record the complete machine running situation of the test equipment through the equipment faults.

Operation steps:

1. Set flow paths of onboard ballast piping valves: Set on sea chest-ballast pump-ballast tank;
2. Set the equipment to "ballast state";

3. Start ballast pump;
4. Start BOS equipment;
5. Shut down BOS equipment after 5min operation (the equipment shuts down after automatically completing a backwash);
6. Set flow paths of onboard ballast piping valves: Sea chest-ballast pump-discharge overboard;
7. Change to set the equipment to "de-ballast state";
8. Start ballast pump;
9. Start BOS equipment;
10. After running for 5 minutes, shut off the BOS equipment;
11. Check equipment alarm record.

During the commissioning for complete machine, the condition of no fault records can be regarded as passing through commissioning. Should there be a fault alarm midway, it needs to interrupt the commissioning, check the alarm source and troubleshoot the system, and make records on troubleshooting.

4.4 Test cycle

For this ballast water management system, a complete test cycle includes:

1) Processing cycle:

Load ballast water with pump→filter→inactivate→load into the

ballast tanks→inactivate→discharge

2) Control cycles:

Load ballast water with pump→load into the control tanks→discharge

A pair of processing cycles and control cycles are conducted simultaneously. Except for “processing operation”, other operations and processes should be entirely identical to the greatest extent.

During the test cycle, take samples at proper positions and time in accordance with the above introduction and properly process, analyze and record the samples.

4.5 Termination procedures

After the test cycle is completed, stop the operation based on O&M manual provided by the manufacturer/R&D institutions of ballast water management system, and make detailed records on the parameters and operations at the end of the procedure.

4.6 Emergency procedures

In case of an emergency during the test, it should be handled according to the established disposal plan in advance. The principle of emergency disposal is to first ensure the safety of personnel and then protect the environment and salvage the properties.

Any emergency during the test should be accurately recorded, carefully analyzed and identified for its reasons.

a. The field operating personnel in the engine room monitor the pipelines at any time and if serious leakage of main pipeline is found, they need to promptly press the emergency stop button of the ballast pump and that of the ballast water treatment equipment;

b. Take the corresponding measures in case of equipment fault alarm;

c. Analyze the equipment data records and alarm records on a regular basis, and find out the hidden dangers.

5 Test report

5.1Description of test time

BOS system began onboard test on COSCO ROTTERDAM in November 2009. COSCO ROTTERDAM is a container liner, 6 test cycles were organized based on the stop time and place of the liner during the onboard test, and the time of each test cycle is as shown in Table 5-1.

Table 5 - 1 Test schedule

Test cycle number	Test operation	Time	Addresses	Witnessed by the CCS or not
The first test cycle	Ballast	November 27, 2009	Zhoushan	Yes
	De-ballast	November 29, 2009	Zhoushan	
The second test cycle	Ballast	November 30, 2009	Zhoushan	No
	De-ballast	December 03, 2009	Shanghai	
The third test cycle	Ballast	December 06, 2009	Shanghai	Yes
	De-ballast	December 07, 2009	Shanghai	
The fourth test cycle	Ballast	January 13, 2010	Shenzhen	Yes
	De-ballast	January 14, 2010	Shenzhen	
The fifth test cycle	Ballast	January 14, 2010	Shenzhen	Yes
	De-ballast	January 15, 2010	Hongkong	
The sixth test cycle	Ballast	June 06, 2010	Shenzhen	Yes
	De-ballast	June 07, 2010	Shenzhen	

5.2 Implementation of test outline

(1) The contents in the outline were completed strictly according to the requirements in the presence of China Classification Society;

(2) All test data were witnessed and recognized.

6 Test results

Article 4, 2.2.2 in G8 guidelines provides that it is required to "present the documentary evidence proving the ballast water after treatment in three consecutive effective test cycles is consistent with D-2 in the Convention during the discharge".

6.1 Raw water quality conditions of onboard test

According to G8, as for the requirements for plankton in inflow water, the inflow water during the 3rd, 4th and 5th test cycles in the onboard test of BOS ballast water management system fully met the requirements, as shown in Table 6-1:

Table 6 - 1 Requirement of plankton concentration in inflow water

Test cycle	Survivable organisms	Concentration	G8 requirements	Evaluation
The 1st test	Plankton ≥50μm (ind/m^3)	2.7×10^4	100	Acceptable
	Plankton ≥ 10-50μm (ind/ml)	1.2×10^2	100	Acceptable
The 2nd test	Plankton ≥50μm (ind/m^3)	6.3×10^4	100	Acceptable
	Plankton ≥ 10-50μm (ind/ml)	1.6×10^2	100	Acceptable
The 3rd test	Plankton ≥50μm (ind/m^3)	3.6×10^4	100	Acceptable
	Plankton ≥ 10-50μm (ind/ml)	1.2×10^2	100	Acceptable
The 4th test	Plankton ≥50μm (ind/m^3)	1.1×10^3	100	Acceptable
	Plankton ≥ 10-50μm (ind/ml)	2.8×10^2	100	Acceptable
The 5th test	Plankton ≥50μm (ind/m^3)	3.1×10^3	100	Acceptable
	Plankton ≥ 10-50μm (ind/ml)	2.3×10^2	100	Acceptable
The 6th	Plankton ≥50μm (ind/m^3)	8.8×10^4	100	Acceptable

test	Plankton ≥ 10-50μm (ind/ml)	90.5	100	Not Acceptable

According to G8, the temperature, salinity, pH and other water quality indicators of raw water used for circulation should be tested, and water quality indicators of onboard test of BOS ballast water management system are shown in Table 6-2:

Table 6 - 2 Inflow water quality indicator

Test items	**Test results**					
	BOS02-Ⅰε-A-Ⅱ	**BOSO2-Ⅱ-ε-A-Ⅱ**	**BOS02-Ⅲ-ε-A-Ⅱ**	**BOSO2-Ⅳ-ε-A-Ⅱ**	**BOSO2-Ⅴ-ε-A-Ⅱ**	**BOSO2-Ⅵ-ε-A-Ⅱ**
Temperature(℃)	19.9	20.5	21.2	19.4	19.7	20.2
Salinity (‰)	31.7	32.1	34.3	31.8	32.1	31.9
pH	7.89	8.04	7.80	8.07	8.15	8.11
Turbidity (NTU)	19.4.	15.5	36.1	6.49	22.52	7.98
Residual chlorine (ppm)	0.08	0.09	0.23	0.07	0.19	0.13
TSS(mg/L)	——	——	37	<5	<5	<5
DOC(mg/L)	——	——	4.36	0.24	0.22	0.24
POC(mg/L)	——	——	0.11	0.04	0.08	0.04

Note: The location of the 3rd test cycle is the anchorage far away from the wharf, namely East China Sea waters. The water sampling season is winter, and according to the hydrological data of East China Sea, it is normal that the salinity reaches 34.3 ‰.

6.2 Biological effectiveness test results

The test results show that, the survivable organisms in the outflow water 3 consecutive (the 3rd, 4th and 5th test cycles) cycles during the onboard test of BOS ballast water management system met the outflow water requirements in D-2, as shown in Table 6-3.

Table 6-3 whether survivable organisms in outflow water meet D-2 or not

Test cycle	**Survivable organisms classification**	**Outflow water concentration**	**D-2 standards**	**Evaluation**
The 1st test	≥50μm (ind/m^3)	3	＜10	Acceptable
	≥ 10-50μm (ind/ml)	4	＜10	
	E. coli (cfu/100ml)	＜30	＜250	
	Enterococcus (cfu/100ml)	0	＜100	
	Vibrio cholerae (cfu/100ml)	Not detected	＜1	
The 2nd test	≥50μm (ind/m^3)	2	＜10	Acceptable
	≥ 10-50μm (ind/ml)	0.82	＜10	
	E. coli (cfu/100ml)	＜30	＜250	
	Enterococcus (cfu/100ml)	0	＜100	
	Vibrio cholerae (cfu/100ml)	Not detected	＜1	
The 3rd test	≥50μm (ind/m^3)	3	＜10	Acceptable
	≥ 10-50μm (ind/ml)	0.69	＜10	
	E. coli (cfu/100ml)	＜30	＜250	
	Enterococcus (cfu/100ml)	0	＜100	
	Vibrio cholerae (cfu/100ml)	Not detected	＜1	
The 4th test	≥50μm (ind/m^3)	0.44	＜10	Acceptable
	≥ 10-50μm (ind/ml)	1.76	＜10	
	E. coli (cfu/100ml)	30	＜250	
	Enterococcus (cfu/100ml)	0	＜100	
	Vibrio cholerae (cfu/100ml)	Not detected	＜1	

The 5th test	≥50μm (ind/m^3)	0.67	＜10	Acceptable
	≥ 10-50μm (ind/ml)	0.7	＜10	
	E. coli (cfu/100ml)	＜30	＜250	
	Enterococcus (cfu/100ml)	0	＜100	
	Vibrio cholerae (cfu/100ml)	Not detected	＜1	
The 6th test	≥50μm (ind/m^3)	1.5	＜10	Acceptable
	≥ 10-50μm (ind/ml)	0.55	＜10	
	E. coli (cfu/100ml)	＜30	＜250	
	Enterococcus (cfu/100ml)	0	＜100	
	Vibrio cholerae (cfu/100ml)	Not detected	＜1	

The test results show that the concentration of survivable organisms in the outflow water from the control tank after onboard test of 3 consecutive cycles by BOS ballast water management system is larger than that stipulated in the D2. Therefore, these 3 consecutive cycles are effective.

Table 6 - 4 Effectiveness evaluation

Test cycle	**Species of survivable organisms**	**Concentration at discharge of control tank**	**G8 requirements**	**Evaluation**
The 1st test	≥50μm (ind/m^3)	9.5×10^3	>10	Acceptable
	≥ 10-50μm (ind/ml)	106	>10	
The 2nd test	≥50μm (ind/m^3)	3.2×10^4	>10	Acceptable
	≥ 10-50μm (ind/ml)	76	>10	
The 3rd test	≥50μm (ind/m^3)	2.3×10^4	>10	Acceptable
	≥10-50μm(个/ml）	35	>10	

	≥ 10-50μm (ind/ml)			
The 4th test	≥50μm (ind/m^3)	1.2×10^3	>10	Acceptable
	≥ 10-50μm (ind/ml)	1.9×10^2	>10	
The 5th test	≥50μm (ind/m^3)	2.3×10^3	>10	Acceptable
	≥ 10-50μm (ind/ml)	1.2×10^2	>10	
The 6th test	≥50μm (ind/m^3)	4.6×10^4	>10	Acceptable
	≥ 10-50μm (ind/ml)	26	>10	

6.3 BOS system complete machine function test results

Routine complete machine functional test of BOS system is conducted during each onboard test. During the test, fault alarm function has been tested properly, and the complete machine runs stably without exceptional faults and anomalies. Since BOS system's fault diagnosis functions cover the state monitoring and recording of the system's valves, transmitters, communications and control lines, UV lamp and other parts, the stability of BOS system during the onboard test shows the system components work stably and reliably and meet the service conditions on ships.

7 Onboard test conclusion

1) BOS system functions stably and reliably and meets the ships' operating requirements;

2) Water quality conditions during the onboard test of BOS ballast water management system are in full compliance with G8.

3) The test results of biological effectiveness in the 3 consecutive and effective test cycles during the onboard test of BOS ship ballast water management system are in full compliance with D2.

4) Installation on the real ship and several tests prove BOS ballast water management system is easy to operate, safe, reliable, and easy for the crew to grasp and use.

AMERICAN BUREAU OF SHIPPING
CLASS SURVEY REPORT

Vessel Name	**COSCO ROTTERDAM**	Class Number	**0240322**
Attending Office	**Ningbo**	Report Number	**NB1748070**
First Visit Date	**05-Nov-2009**	Last Visit Date	**13-Nov-2009**

THIS IS TO CERTIFY that the undersigned surveyor(s) to this Bureau, did at the request of the Owners representative attend the Container Carrier COSCO ROTTERDAM, of Port London, United Kingdom of Great Britain and Northern Ireland, Class Number 0240322, IMO Number 9221073, on 05-Nov-2009 as the vessel lay afloat, in order to carry out the survey(s) noted below:

Survey Location: Zhoushan, China

Report	Survey Description	Status	Outstanding
NB1748070_A	Other Survey (Class) - Modification Survey - examination class related items of BWMS installation	Completed	No

Safety Management System Section (IACS PR 17)

No deficiencies were observed during this survey relating to possible Safety Management System failures.

Closing Paragraph

It is recommended that this vessel be retained as classed with this Bureau.

Surveyor(s) to The American Bureau of Shipping
Attending Surveyors

Luo Heng (Peter) — Electronically Signed on 01-Dec-2009

Reviewed By

So, Wing Wah — Electronically Signed on 08-Dec-2009, Shanghai Port

AMERICAN BUREAU OF SHIPPING
CLASS SURVEY REPORT

Vessel Name	**COSCO ROTTERDAM**	Class Number	**0240322**
Attending Office	**Ningbo**	Report Number	**NB1748070**
First Visit Date	**05-Nov-2009**	Last Visit Date	**13-Nov-2009**

NB1748070_A : Other Survey (Class) - Modification Survey

Statement/Observation

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This Ballast Water Management System (BWMS) was jointly developed by COSCO Group and TSINGHUA University (P.R.China).

1. The system was under type approval process by CCS on behalf of MSA, P.R.China as per IMO convention.
2. This ship is the first ship to install this BWMS, it is just under on board test purpose as per IMO Guidance.
3. As ABS, the review and survey scope of BWMS installation is limited to the classification requirements for the related systems and the Ballast Water Treatment Equipment itself is out of the scope of our review and survey, and this system was not for substitution of current Ballast Management Procedure on board. The modication on piping, structural, electrical, pressure vessels related to the classification requirements was examined in accordance with drawings approved by ABS Shanghai as per review letter ref. XJ/PZ dated 4 Nov 2009 and found satisfactory.

P-001	**Drawing Title**	Drawing		
	Drawing Number	NA		
	Status	Closed	**Comment Action Type**	Surveyor
	Submitter	COSCO MARITIME (UK) LIMITED	**WCN**	822157
	Opened In	Project No: 2256792	04-Nov-2009	Jin, Xing
	Closed In Report	NB1748070-Other Survey (Class) - Modification Survey	10-Nov-2009	Ningbo
	Engineering Office	Shanghai Engineering Services	**Facility No**	**0240322**
	Engineering Comment	DWG "P-5 Ship Service&Control Air System", If the air reservoir is within the scope of 4-4-1/1.1 of SVR2009, it is to be certified by ABS.		
	Description			
	Task Number	520628		
	Observation	The system maximum working pressure is less than 7kg/cm2, also on the system has the relieving valve (setting pressure:6.8 kg/cm2), so, the air reservoir is not within the scope of 4-4-1/1.1 of SVR2009.		

P-002	**Drawing Title**	Drawing		
	Drawing Number	NA		
	Status	Closed	**Comment Action Type**	Surveyor

AMERICAN BUREAU OF SHIPPING
CLASS SURVEY REPORT

Vessel Name	**COSCO ROTTERDAM**	Class Number	**0240322**
Attending Office	**Ningbo**	Report Number	**NB1748070**
First Visit Date	**05-Nov-2009**	Last Visit Date	**13-Nov-2009**

Submitter	COSCO MARITIME (UK) LIMITED	**WCN**	822157
Opened In	Project No: 2256792	04-Nov-2009	Jin, Xing
Closed In Report	NB1748070-Other Survey (Class) - Modification Survey	10-Nov-2009	Ningbo
Engineering Office	Shanghai Engineering Services	**Facility No**	**0240322**
Engineering Comment Description	DWG "P-5 Ship Service&Control Air System", The air reservoir is to be provided with its own relief valve or equivalent devices. See 4-6-2/9.9.5 of SVR2009.		
Task Number	520628		
Observation	verified		